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Petroleum Refiner

NOVEMBER
1959

'59 PETROCHEMICAL HANDBOOK p. 183

102 process descriptions showing flow diagrams

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- Fluorochemicals
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- Fibers
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- Olefins
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AS MANAGEMENT SEES IT

Idea Acceleration--Key to Progress 357

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Petroleum Refiner
OIL, GAS AND PETROCHEMICAL PROCESSING

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A Quick Look at This Issue

These handy digests permit checking the articles you want to read first.

PETROCHEMICAL HANDBOOK

☐ **Petrochemicals—Still Growing Fast! . . .** Research into new products and new processes helps maintain petrochemicals dynamic growth. For highlights of the areas you should watch, turn to **Page 189.**

☐ **Synthetic Detergents . . .** continue their upward climb at the expense of soap. More specific new applications appear to be the key to this growth. For the latest on this picture, turn to **Page 191.**

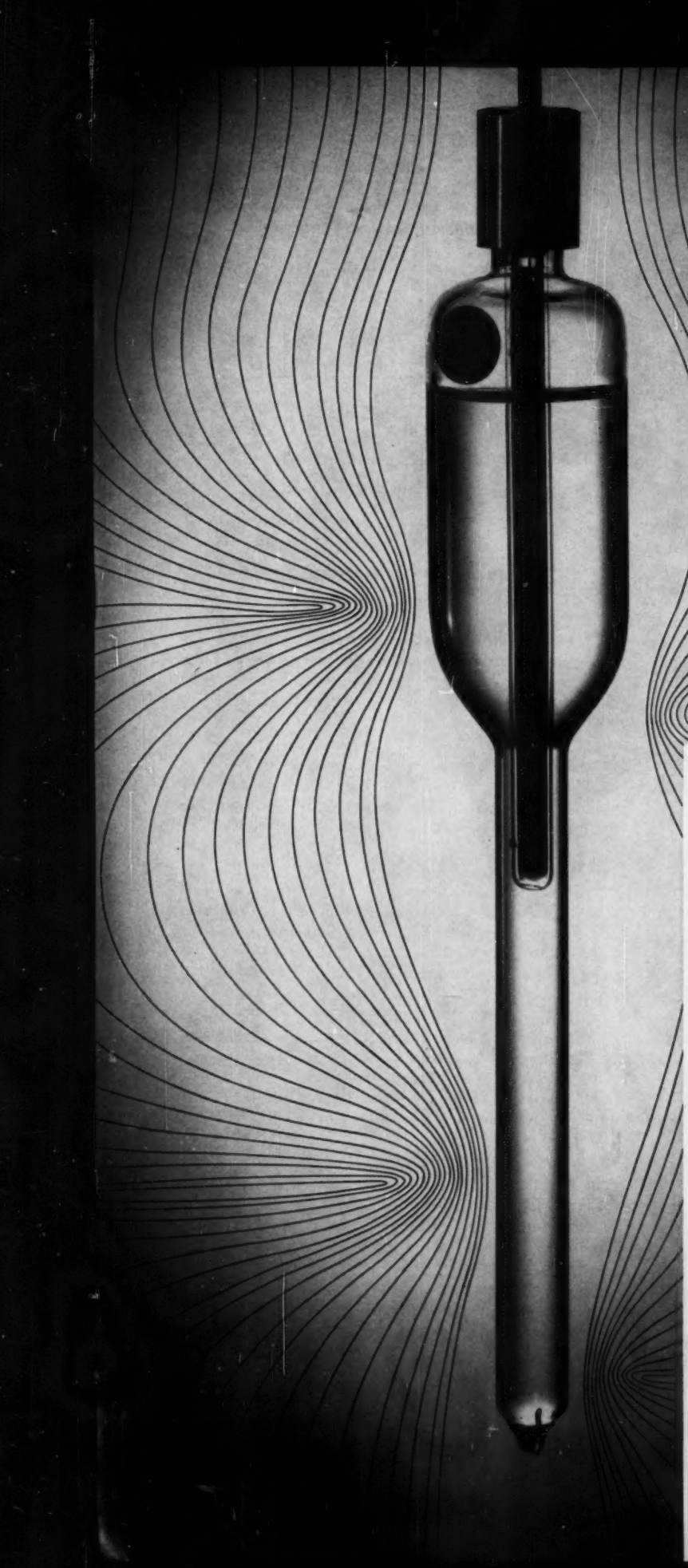
☐ **Pesticides . . .** Despite the cutback in agricultural acreage and foreign competition, the consumption of petrochemicals in pesticides continues to grow. For a look into the future and a careful study of this industry's problems, turn to **Page 192.**

☐ **Synthetic Fibers . . .** have grown remarkably in spite of the over-all increase in total fiber production. Universal acceptance and development of new fibers point to continued growth. For a complete look into this petrochemical field, turn to **Page 193.**

☐ **Plastics . . .** are predicted to grow twice as fast as the industrial average for the next seven years. For leaders in this field and trends to watch, turn to **Page 194.**

☐ **Aromatic Hydrocarbons . . .** from petroleum will grab an increasing share of this market in the future. With octanes continuing to climb, chemical use

Please Turn Page ➜



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A Quick Look at This Issue . . .

of BTX aromatics will use only a small portion of the available supply. For a look at this important phase of petrochemicals, be sure to turn to **Page 196.**

☐ **Olefins . . .** continue to be the life blood of the petrochemical industry. For areas of new growth as well as fields just now being developed, turn to **Page 197.**

☐ **Fluorochemicals . . .** have shown a steady expansion over recent years, yet have presented a somewhat confused growth pattern. For a complete look at this picture, turn to **Page 198.**

☐ **Synthetic Rubber . . .** is bounding back in 1959 as consumption will reach an all time high. For a look at new developments and expanding markets into established fields, turn to **Page 199.**

☐ **Operator's Handbook for Gasoline Plants . . .** This part on reciprocating pumps is one of a series which simplifies operations and equipment for the new and experienced operator in a natural gasoline plant. Every operator should know at least this much about pumps, which starts on **Page 307.**

☐ **Idea Acceleration—Key to Progress . . .** Facts and timing are necessary for the birth of new and good ideas—and one of the best "idea-reactors" today is the meeting. Of course, many meetings are a waste of time and energy, but properly handled they can produce chain reactions of creativity. You'll find this article both interesting and informative, so turn to **Page 357.**

☐ **Where Is Your Company Headed? . . .** You should study where your organization will probably go even if management makes no long-range plans. This is known as the "momentum factor"—and here's how you can investigate it in full detail. Turn now to **Page 361.**

☐ **The Hazards of Static Electricity . . .** Many disastrous fires and explosions have been attributed to static electricity. Here is an article, however, which will help you understand the methods which should be used for static protection—and the problems that accompany them. Turn now to **Page 367.**

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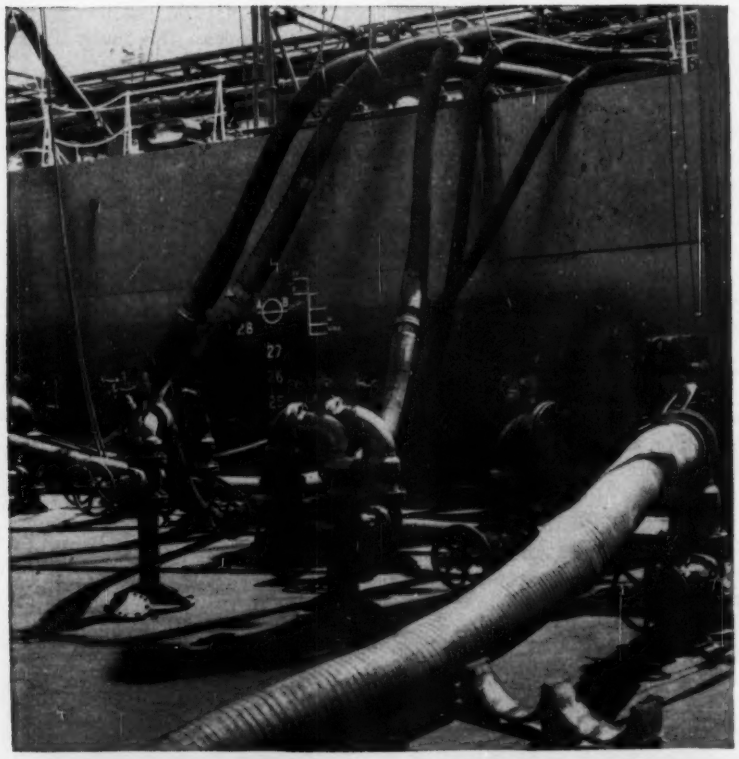

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Regular Doses

IN THE MATTER of safety and fire prevention, PETROLEUM REFINER continues to excel all magazines in its field. Six and a half years ago an editor was named for "As Management Sees It" (Page 357 in this issue), and he was assigned certain broad fields, one of them being Safety and Fire Prevention. Considerable success has crowned our efforts ever since. In 1958, for example, PR published eight feature articles, one editorial and innumerable news items on safety alone. For this PR received a special Public Interest Award and plaque from the National Safety Council. Nor have we rested during 1959 on these laurels. Since January we have presented eight valuable features dealing with safety with at least one booked for both November and December. Rather than an occasional special, we hold that safety is so important that good safety material should be printed as soon as we get it. So instead of splashing with a big special, we'll present ours on a regular, continuing basis in hopes that some of the costly and unsafe practices in petroleum processing plants will be avoided.

Using the Card

PETROLEUM REFINER, of course, endorses the circle that operates among engineers interested in current literature relating to the oil, gas and petrochemical processing industries. A Brooklyn subscriber who was asked to suggest names of colleagues who might like to receive copies of PR describes it this way: "Most of my friends who are interested in material as presented by PR already are subscribers. In fact, it is from one of them that I received *my* subscription card. Should I meet anyone else in refining work interested in such articles I will be happy to use the card and forward their names to your subscription department."

The friend and, of course, PR will be grateful for such thoughtfulness.

Solid with Subs

PRESENTATION OF its technical feature articles as a solid block of pages draws favorable comment almost every time you hear from or talk to a PETROLEUM REFINER reader. "The main technical content doesn't wander into the back of the book through a lot of fractional pages," is one reason given by a subscriber for preferring PR. Then, interesting comment came from an editor of one of our contemporaries in the field of oil, gas and petrochemical processing: "Yeah, PR does a better job than ——— because the technical material is not mixed up with the ads. Their feature technical section makes a tremendous impact because it is handled in a solid, unified manner."

PR adopted this block presentation back in the 20's not long after the initial issue appeared and readers have been applauding the idea ever since.

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Quick Look at Industry...

Automation Big Point In Kaiser O. K. . . .

One big point not being ballyhooed in agreement between Steelworkers and Kaiser sets up joint union-management committee to deal with problems of automation. What it boils down to is any savings in labor costs must be made by "mutual agreement"—which means union can veto them. This committee is Kaiser-McDonald answer to industry demands for changes in old contracts to give management freer hand in revising local work practices. McDonald charges this demand would give management "black-snake whip to use on backs of workers."

Actually, problem has been worrying unions for some time. Many feel use of the strike as weapon grows weaker as automation spreads—with fewer people serving public and running plants, it gets harder to halt production. Secretly, labor leaders know they can't permanently halt automation, but feel they can spread it thin over long period. Kaiser agreement will give many unions big stick to carry to bargaining table. Look for many to wield it.

More Mergers on the Oil Scene . . .

El Paso Natural Gas buys minority interest in Odessa Butadiene and Odessa Styrene from United Carbon—gives El Paso 100% of the Styrene company and 75% of the Butadiene company . . . Standard Oil (Ohio) acquires Leonard Refineries, Alma, Mich.—Leonard has 21,500-bpd refinery in Alma and 7,700-bpd plant in Mt. Pleasant, Mich. . . . Resolution to merge Suntide Refining into Sunray Mid-Continent approved by Sunray's board. Suntide operates 55,000-bpd plant in Corpus Christi.

CRC Announces Isocracking . . .

California Research has new process for hydrocracking petroleum distillates at low temperatures and pressure. Called Isocracking, typical feeds are heavy cracked naphthas, light cycle oils and coker distillates. Product is gasoline blend stock, which after moderate reforming, has research octane rating of 103-105 F-1 with 3 ml TEL. Payout: under 2 years (more on Page 376).

Synthetic Rubber Outlook Brightens . . .

With estimates of natural rubber consumption bouncing above expected production, looks like synthetic will be filling many needs. Short supply of natural usually indicates price rise whereas synthetic always maintains steady price as well as abundant supply. Synthetic will probably get the nod even in some cases where natural is available.

Panning the Building Scene . . .

Texaco to expand Pointe-a-Pierre refinery from 135,000 to 235,000 bpd within a year. Cost: about $18 million . . . Phillips Chemical to expand ethylene capacity at Sweeny, Texas—will hike plant's annual capacity to 290 million pounds . . . Australian Synthetic Rubber awards contract for Australia's first synthetic rubber plant. Fluor International will build the $10-million facility at Altona, near Melbourne—on stream date sometime in '61 . . . Poland will build $25-million refinery near Plock on Ukraine-East Germany crude line—same site as planned petrochemical complex.

Oil Companies Share Big Business . . .

Position of oil companies in over-all big business picture held steady in last five years says recent report. Oil companies in nation's top 500 industrial corporations (in terms of sales) accounted for 17.05% of the sales in '58—negligible change from the 16.44% share grabbed in '54. Big oil accounted for about one-fourth of group's assets and 8% of its working force in both years.

New Firm in Belgium . . .

Amoco Chemical and Petrofina, Brussels, form new company, Amoco Fina, S.A., to make and sell petroleum additives in European common market. Plant at Antwerp slated to go on stream in '61.

Results of Explosion Study . . .

Explosion at Cities Service Ponca City refinery Jan., 1959 was not new modern unit, but reliable coking process in operation over 30 years. Complete blast study reveals:

1. Detonation possible in any process where air is present, assuming other contributory conditions.
2. Startups continue as most vulnerable period of any unit operation.
3. Startup procedures of old units should be reviewed in light of latest technology. Any addition or deletion to regular startup procedure must be studied for remote combinations of conditions resulting in hazards.
4. Side-by-side operating units not desirable.
5. Platform grating probably makes less destructive missiles than floor plate.

Focusing on the Octane Picture . . .

Octanes are still on the rise. Last month Premiums remained unchanged by holding steady at 99.2 F-1. Regular climbed to an all-time high of 92.2 F-1—up .1 from Sept.

Amoco Strike Gulf Coast's Longest . . .

As of Nov. 10, strike at Amoco's Texas City refinery passed 133-day mark to become longest oil worker walkout in Gulf Coast history. Previous record was 118 days and came in 1950 against Texaco plant at Pt. Arthur.

Why the DuPont Move? . . .

Much head scratching over DuPont's entry into the acrylonitrile field—a petrochemical market already facing overcapacity. Some say DuPont's plan for second acrylo plant at Beaumont stems from natural desire to be self-sufficient. Others contend newly developed process based on ammonia and propylene could be technological breakthru to further lower prices. One more reason is possibility of another large user of copolymers based on acrylonitrile ready to come on the scene. But one thing is certain—all over-capacity will face more and stiffer competition.

Quick Look Around the World . . .

Radio Peking claims Red China's 1958 crude output averaged 45,000 bpd—also said oil shale deposits found in Karemai and Tsaidam in northwest and central Szechuan fields . . . Official Brazilian trade mission to visit Russia late this month to discuss reopening direct trade—one goal: to get refinery and other Russian equipment in exchange for coffee and surplus agriculture . . . Grace Chemical to manage and operate Gonzalez Chemical's ammonia and ammonium sulfate plant in Guanica, Puerto Rico—probably is first step in reorganization which will see Grace take over large portion of Gonzalez stock.

United Refining keeps expanding—first Unifiner in 1953, second in 1959—both designed by Blaw-Knox.

Now on stream: a new hydrogen treating system at United Refining Company's Warren, Pennsylvania, refinery. The system upgrades naphtha used as feed stock for catalytic reforming. The Unifiner, together with modifications Blaw-Knox made to the catalytic reformer, increases output of high octane gasoline. United Refining and Blaw-Knox worked together to install the *first* application of this process in 1953. Since then, Blaw-Knox has designed eight other hydrogen treating units with capacities ranging up to 15,000 barrels a day. Process pioneering requires a fresh outlook and technical skill found at Blaw-Knox. For details, contact Blaw-Knox headquarters in Pittsburgh, Pennsylvania. Branch offices in New York; Haddon Heights, New Jersey; Washington, D.C.; Birmingham; Chicago; and San Francisco. *Plant builders for industry . . .*

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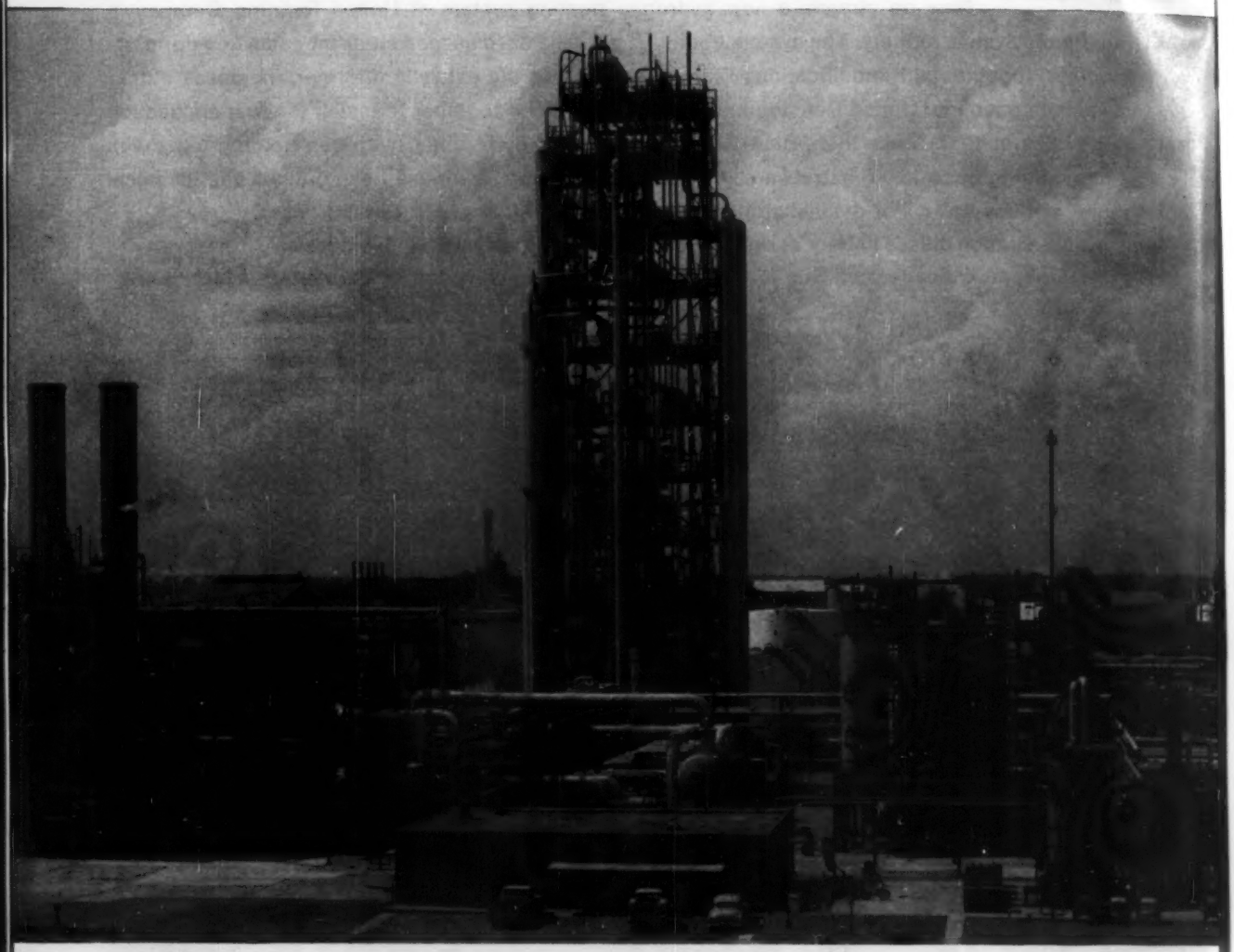
Unifining system comprises stripping tower (left), horizontal flasher drum and heat exchanger train, vertical heater, and the reactor. This system is a process licensed by Union Oil Company of California and Universal Oil Products Company.

World's Largest Ethylene Unit



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Another Union? But Take a Look . . .

IT WAS A COLD GRAY MORNING when Joe Jones, maintenance supervisor walked out to the No. 2 cat cracker. Clinging to his side like a couple of cocker spaniels were two stewards, each yapping something about claiming a certain job for their craft.

Joe was trying to listen patiently but his mind kept wandering back to troubles on the cracker's regenerator. He really likes to solve maintenance problems on the units but ever since he was made maintenance supervisor, jurisdictional disputes kept gnawing away at his time.

Sometimes Joe wondered why management didn't hire one of their industrial relations lawyers as maintenance supervisor. It was just one round after another of arguing over who worked where and when. He is a maintenance engineer and a good one; and it's a waste of talent having him handle labor problems when he could be keeping the units on stream.

What's the Job? Yes, it seems strange that a maintenance supervisor's big job is scheduling craft work to avoid jurisdictional squabbles. It's strange because his job is supposed to be supervising the maintenance program in his plant instead of refereeing a bout between two stewards claiming the same job for their craft.

The present labor setup in union plants is virtually impossible to administer efficiently. The result is needless downtime of production equipment. Supervisors have to devote too much time to minute planning in order to schedule all of the crafts which can possibly make jurisdictional claims to the work. Or, failing to do that, they are compelled to devote even more time to discussing or hassling with stewards over alleged jurisdictional errors.

One supervisor said recently, "it may be strange but it's just the way things are and until you get rid of unions, things ain't gonna change much." Now that kind of talk is typical of many plants in the oil business.

The unions aren't *all* bad. They couldn't have existed this long if they were. One of the main troubles in the petroleum processing business is that the unions are just about as backward as some of the supervisors and management.

You say, "we know about all these problems but what's the answer, particularly where you have a union shop?"

Well, it seems that in modern, complex petroleum processing plants a new approach is needed in providing maintenance labor. Successful in many non-union plants for some time, the idea simply calls for using multiskilled mechanics.

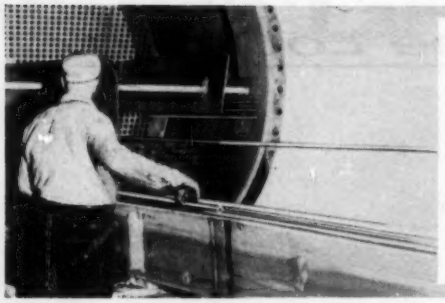
Here's the Idea. Your present union setup probably does not permit using multiskilled mechanics. But, suppose a new type of union was formed—the Plant Mechanic's Union. Men in the plant's existing crafts who show an aptitude for multicraft work could be trained along the lines of a machinist and millwright to take care of minor repairs on pumps, compressors, conveyors and other mechanical equipment in his plant. They could be trained for a lot of pipe work and could also be trained to do the boilermaker's work of opening a heat exchanger in order to tighten a few leaky tubes with an expander. There is no need for them to be skilled milling machine operators or to know how to form a heavy steel plate cone with boiler shop machinery. Specialized craft work will always have to be performed by journeymen skilled in that particular line of work. The plant mechanic is not a substitute for these journeymen; therefore, they will not displace them.

The plant mechanic's biggest criticism would be that he is a jack-of-all-trades and master of none. This, of course, would not be true because he is a master of the plant mechanic's trade.

Remember the supervisor who said, "things ain't gonna change much." Well, they surely will not unless some new ideas are promoted. Here's what we think is a relatively new approach. Top management would do well to get behind the idea and sell it to the union. It certainly can't hurt the union to have another craft added to their flock and it will assist maintenance supervisors tremendously in performing their job—supervising the plant's maintenance operations.

The unions wouldn't lose a single man because the nucleus of this new craft would come from the rank and file of craftsmen presently working in the plant.

Keep this in mind: All crafts would *not* be integrated into this new craft called plant mechanic. Only those skills required to perform normal routine maintenance would be concerned. Even in plants where multiskilled mechanics are commonly used,



CONDENSER AND HEAT EXCHANGER CLINIC

Edited by A. W. Tracy, Metallurgical Engineer
The American Brass Company, Waterbury, Conn.

OPERATING FACTORS THAT AFFECT CONDENSER TUBE LIFE

Answers to some of the questions sent in following a previous clinic on this subject

Q. How effective is chlorination as a preventive maintenance procedure in cleaning tubes fouled by polluted water?

A. The chlorination of polluted sea water has been found to be effective in removing or preventing the formation of slimes on the walls of tubes. Better cleanliness was indicated by higher vacuum obtained on the steam side of the condenser. Tubes kept clean by chlorination have been reported to be less subject to pitting. It should be interjected here that tubes carrying polluted sea water containing sulfides from decomposition of organic matter seldom undergo inlet end corrosion, but the remainder of the length of the tubes often becomes pitted. Clean sea water, if entering the tube turbulently, will often cause corrosion at the inlet end, and usually the remainder of the length of the tube is coated with a good protective film of corrosion products.

The statement that chlorination may break down sulfide films on the walls of tubes is based on the fact that chlorine is an oxidizing agent and would oxidize sulfides; however, it is realized that the usual chlorine treatment would probably not remove thick long-standing sulfide scales.

Q. How often should tubes be cleaned and what are some of the methods used?

A. The required frequency of tube cleaning depends, of course, on how rapidly the tubes become fouled. In some power plants, tubes are cleaned once a week; at other stations, cleaning is required only at intervals of several months. Often the decision to clean tubes is determined by the drop in vacuum on the steam side.

In regard to methods for removing accumulations from condenser tubes, some station operators shoot rubber plugs through the tubes; others use bristle brushes, either of animal hair or nylon. The use of brushes is reported by some to do a better job of cleaning than the use of plugs.

An interesting method for continuously cleaning condenser tubes has been developed in Europe. A large number of sponge rubber balls, slightly larger in diameter than the inner diameter of the tubes and having about the same specific gravity as sea water, is fed continuously into the inlet water box. The cooling water forces the balls through the tubes, and deposits on the tube walls are swept away. The balls are collected by a cone in the outlet water box. They leave the water box through a tube connected to the end of the cone and are recirculated into the inlet water box. By the law of probability, each tube will eventually receive a ball. The system is not applicable to tubes that have been in service and have become rough and pitted.

Some stations periodically remove deposits from tubes by recirculating a dilute, inhibited hydrochloric acid solution through the condenser.

Q. How important are temperature and velocity as factors in the service life of condenser tubes?

A. Corrosion of condenser tubes is usually more rapid in summer than in the winter, but pollution due to bacterial action in the summer may be a more important factor than temperature itself. Instances have been observed where failures in a set of tubes occurred only in the warm-water months and none in the cold-water months, over a period of several years.

Mention was made in the clinic to the effect that high temperature of water causes pitting, due to the formation of gas bubbles on the tube wall. This type of pitting occurs most frequently, but not often, in oil refinery condensers where temperatures on the vapor side may be as high as 350F and water velocities relatively low. In a power plant condenser, temperatures on the vapor side ordinarily do not exceed 100F and temperature rise in the cooling water from the inlet to the outlet end is usually limited to 10F.

TECHNICAL ASSISTANCE. Our Metallurgical Department is regularly helping manufacturers, electric power companies, marine operators, petroleum and chemical companies to select the correct tube alloy for many types of condensers and heat exchangers. This service is available to you without obligation. Write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

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certain specialized skills, such as instrument and electrical repairs are performed along single craft lines. Another point that needs re-emphasis is the fact that single line craftsmen would still be needed where exceptional skill is required to maintain the equipment.

The real problem lines in getting such an idea started. It would require that a convinced, determined top management back the idea. They would have to present a practical, step-by-step proposal to top union officials and convince them that the plan is best for everyone concerned.

Which might not be too easy, but any new idea takes a lot of talking. It wasn't very long ago that the 40-hour work week was just a conversation topic. Perhaps the day will come when jurisdictional disputes are a thing of the past—multicraft mechanics surely seem like one answer at least, in the oil processing industry.

Game With Familiar Rules

A BUNCH OF THE BOYS were just sitting around playing a little poker the other night when one of the players looked up and said, "What we need to do is invent a poker game where everybody wins."

Of course we all laughed at first. Then someone ventured that this really would be a good idea and the more we talked about it the better it sounded. So, we began to give it some serious thought—could we actually come up with a poker game where everybody would win?

"This would really be terrific," said Clem who owns a little farm just outside of town. "If I could just win enough so that I wouldn't have to plant a crop this year I could do a lot of things I have been putting off for years."

"That sounds O.K.," I told him. "Here's what we'll do, Clem. We'll let you win enough to pay you for not planting a crop this year. Besides, there's plenty of acreage around here and without your crop there will be enough of a shortage to keep the prices up for the rest of the farmers in the area."

"Swell," Clem agreed, "that will make everybody happy!"

"Tell you what I'd like," said one of the players named Pedro. Actually Pedro is not a regular member of our poker club—he's an official of a foreign government who's just visiting our town for a while.

Even a Repeat Basis. "What I'd like," Pedro repeated, "is to win enough money so our government could start a couple of industries back in my country."

"Sure, and you can come back at least once a year —and more often if you really get in a bind," we told him. "But since you will win this money in our poker game, you must promise that you will always like us."

"Agreed," said Pedro with a broad grin.

"Say, I have a terrific idea," piped up Jim.

"What is it?" asked a couple of the others in unison. Everyone seemed excited with the idea now.

"Let's take a small portion out of the kitty every now and then and put it in a special account down at the bank. Then after a few years we'll have a real nest egg to support all of us when we get too old or lazy to work."

"That's a great idea," I cried, "We'll just take out a small handful every so often, and in that way it won't be missed. Besides that, we could even give it a name. Let's see . . . how about Socialistic Security?"

"Oh, no," Jim responded quickly, "I don't want to have anything to do with socialistic schemes. Let's call it 'O. A. Security'—for 'Old Age Security'."

Everyone around the table nodded his agreement, then I spoke up as a thought came to mind. "You know, here's a good chance for us to fix up the old schoolhouse and to build a new bridge across Holler Creek. We could take a little out of the kitty for that."

"But I thought the state and local governments were supposed to handle that," Clem drawled.

"Usually they do," I countered, "but look at the money we would not have to pay in state and city taxes if we could take care of these projects from the game."

"Guess you're right," Clem admitted.

It's "Federal Ante." Since no one came up with anymore suggestions right away, we decided to start devising the game—this poker game in which everyone would be the winner. The first suggestion came from Bill.

"I'll tell you what," he said. "Since the word 'federal' means a union or joining, let's call our game the 'Federal Ante' and that will show that we all have a stake in it."

"Good, good," we all cheered.

From then on, the ideas did not flow so freely, but finally after a while we settled on a set of rules where everyone would win. As we started to deal the first hand, we were all elated and rather proud for having come up with such an astounding idea. Personally I was at a loss as to why no one had thought about it before.

However, as we all threw in our usual ten-cent ante, those six dimes looked pitifully small for all we needed to win, so we upped the ante to a quarter. Still, this didn't look like enough, so we decided that since Jim had more chips in front of him than anyone else, he should ante more than the rest. At first Jim objected, but we told him that if he wanted to play, this is the way it would be, so he went along, although a bit reluctantly.

But even with some of the players anteing more than others, it was apparent that the pot was going to require a lot more. In our haste apparently we had forgotten to consider that the pot had nothing except our own contributions. In other words, it could only give back what we had put in in the first place.

As we all sat there looking at the small stack in the middle of the table I could see the faces of the others reflecting the same thoughts which were running through my mind. And as I looked around I suddenly got the sensation that I had been through this whole situation before. I couldn't quite put my finger on it, but everything seemed so familiar . . .

ETHYL ANNOUNCES A NEW

"Motor 33 Mix" an important forward step in improving antiknock cost effectiveness

What is it? After years of exhaustive research in the antiknock field, Ethyl introduces to the petroleum industry "Ethyl" Antiknock Compound-TEL-Motor 33 Mix.

This new Motor 33 Mix is an improved and patented formulation incorporating manganese with tetraethyllead, and is the first major advance in antiknock chemistry since Ethyl introduced tetraethyllead.

What does it do? This new development will provide many benefits to both the refiner and the motorist.

1. 33 Mix makes possible a higher antiknock quality than with present antiknock compounds at the same concentrations.

2. 33 Mix improves gasoline's response to TEL making possible octane improvement at lower cost. The charts to the right show this cost effectiveness.

3. 33 Mix provides extra dimension in refining flexibility.

- 33 Mix permits greater use of natural gasoline or virgin light naphtha, economically improving road antiknock performance.
- 33 Mix offers refiners an opportunity to review future plans and delay or eliminate purchase of refining equipment for octane improvement.
- 33 Mix may enable refiners to reduce the amount of aromatics in gasoline through less severe catalytic reforming. This produces better road performance and increases gasoline yield.

How does it work? In Ethyl's new antiknock compound, there is a small quantity of manganese (.05 gram/milliliter of TEL) that has a "promoter" effect on tetraethyllead. This "promoter" effect increases with increasing TEL concentration. It varies with the hydrocarbon composition of the gasoline and, therefore, will vary with the refining situation. This suggests the possibility of selective blending and refining to take advantage of the economics of this new antiknock compound.

The most dramatic demonstration of this "promoter" action can be seen in alkylates and gasolines containing a high percentage of isoparaffins. Note on the charts that fuels showing good response to TEL show excellent response to Motor 33 Mix.

How has it been tested? Before announcing 33 Mix, Ethyl spent several years subjecting this new development to tests in 3 basic areas—in the laboratory, on the road and in trial markets. Here are some of the tests 33 Mix underwent:

1. Laboratory Tested—over 100,000 hours of dynamometer laboratory testing with both single and multicylinder engines, to determine its suitability in engines. In addition, 10,000 road ratings were made to establish its effectiveness in various gasolines.

2. Road Tested—more than 7,000,000 vehicle miles in passenger car test fleets. In addition, employee-owned automobiles ran up another 1,500,000 miles of testing. No problems of any magnitude were encountered.

3. Market Tested—thirty-one companies, both large and small, participated in actual trial marketing tests for six months. Over 125,000,000 gallons of treated gasoline were sold to the public across the country with highly satisfactory results.

Further details: For complete details on how 33 Mix can be most advantageously applied to your refining situation, call your Ethyl Representative.

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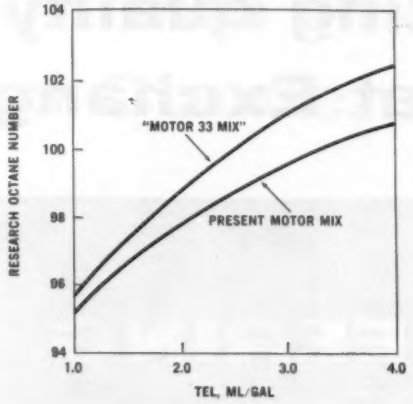
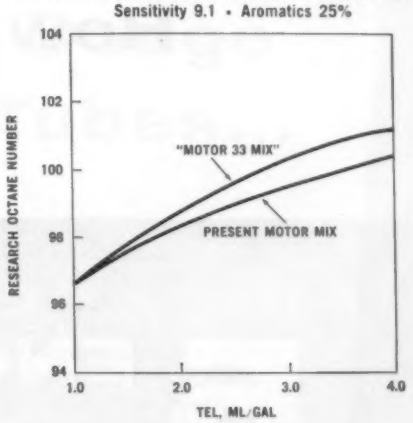
Sensitivity 8.8 • Aromatics 25%



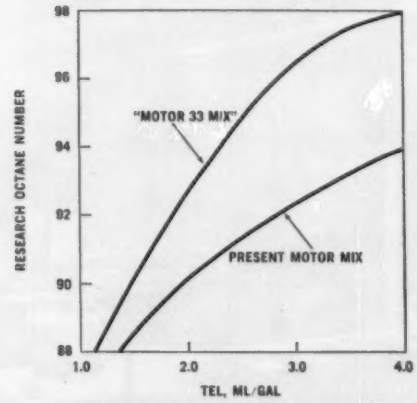
1. The octane improvement costs for the additional octane gained by using Motor 33 Mix are 4.2¢/RONB at the 2 ml TEL level and 4.0¢/RONB at the 3 ml TEL level in the octane range from 98 to 103 RON. Cost figures are very favorable since average processing cost for premium gasoline is about 12¢/RONB.

PREMIUM GASOLINE WITH AVERAGE ANTIKNOCK RESPONSE
Sensitivity 9.1 • Aromatics 25%



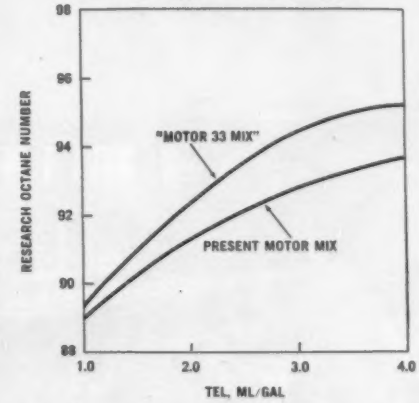
2. Octane improvement costs in this case represent a more typical premium fuel. Antiknock improvement with 33 Mix costs 8.8¢/RONB and 8.7¢/RONB at the 2 and 3 ml/gal TEL levels respectively—and this in the octane range from 98 to 100. Again, very attractive figures when compared to processing improvement costs.

REGULAR GASOLINE WITH GOOD ANTIKNOCK RESPONSE
Sensitivity 2.8 • Aromatics 11%



3. This is a case of regular gasoline with very good antiknock response, typical of premium or regular gasolines with low sensitivity. Antiknock improvement gained by using the new compound is extremely low cost: 2.9¢/RONB at the 1 ml TEL level and only 1.5¢/RONB at the 3 ml TEL level—a favorable comparison with average cost by processing for regular gasoline of 5¢/RONB.

REGULAR GASOLINE WITH AVERAGE ANTIKNOCK RESPONSE
Sensitivity 6.6 • Aromatics 20%



4. This represents a more typical regular gasoline, and here again octane costs suggest the use of the new antiknock. As with most fuels, this is especially true at the 3 ml TEL level where the promoter effect is most prominent. At this point, octane improvement cost with 33 Mix is 3.5¢/RONB—a saving of 1.5¢/RONB for this additional octane improvement when compared with cost by processing.

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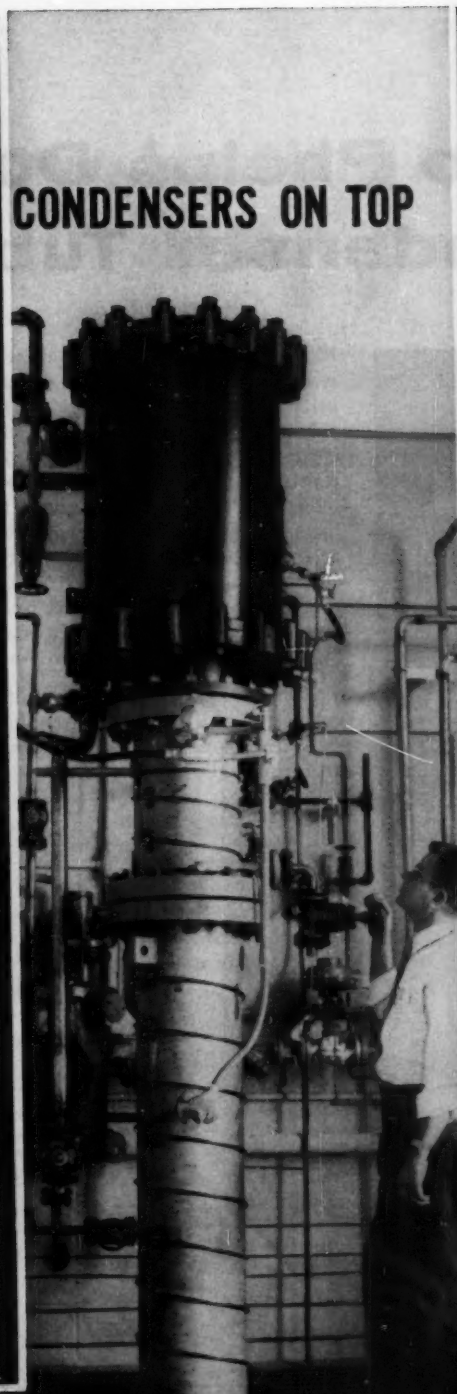

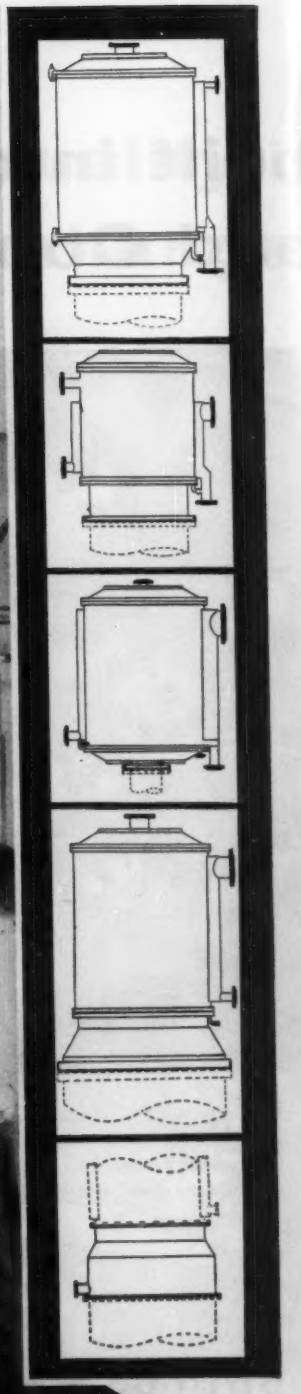

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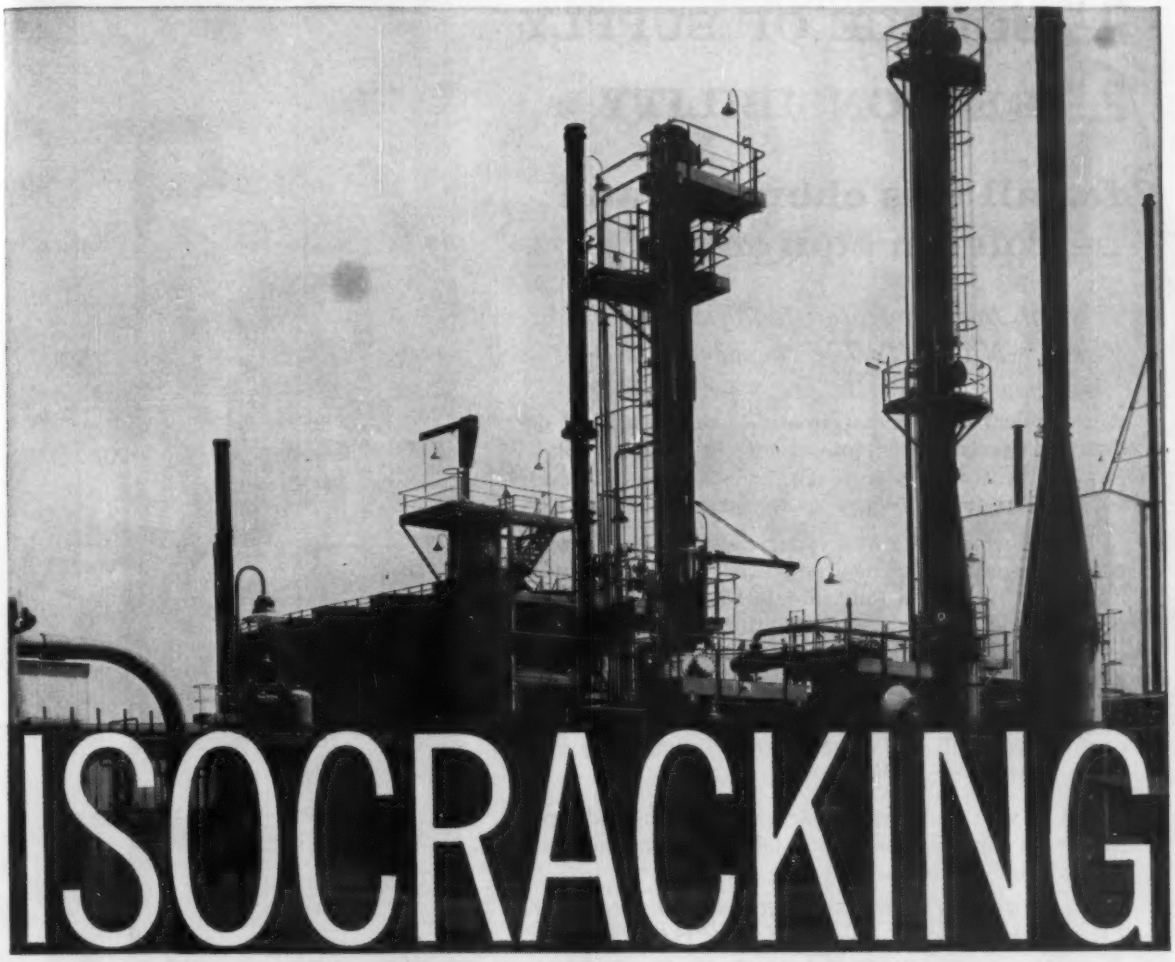

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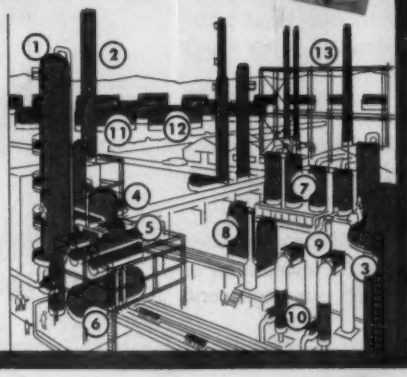

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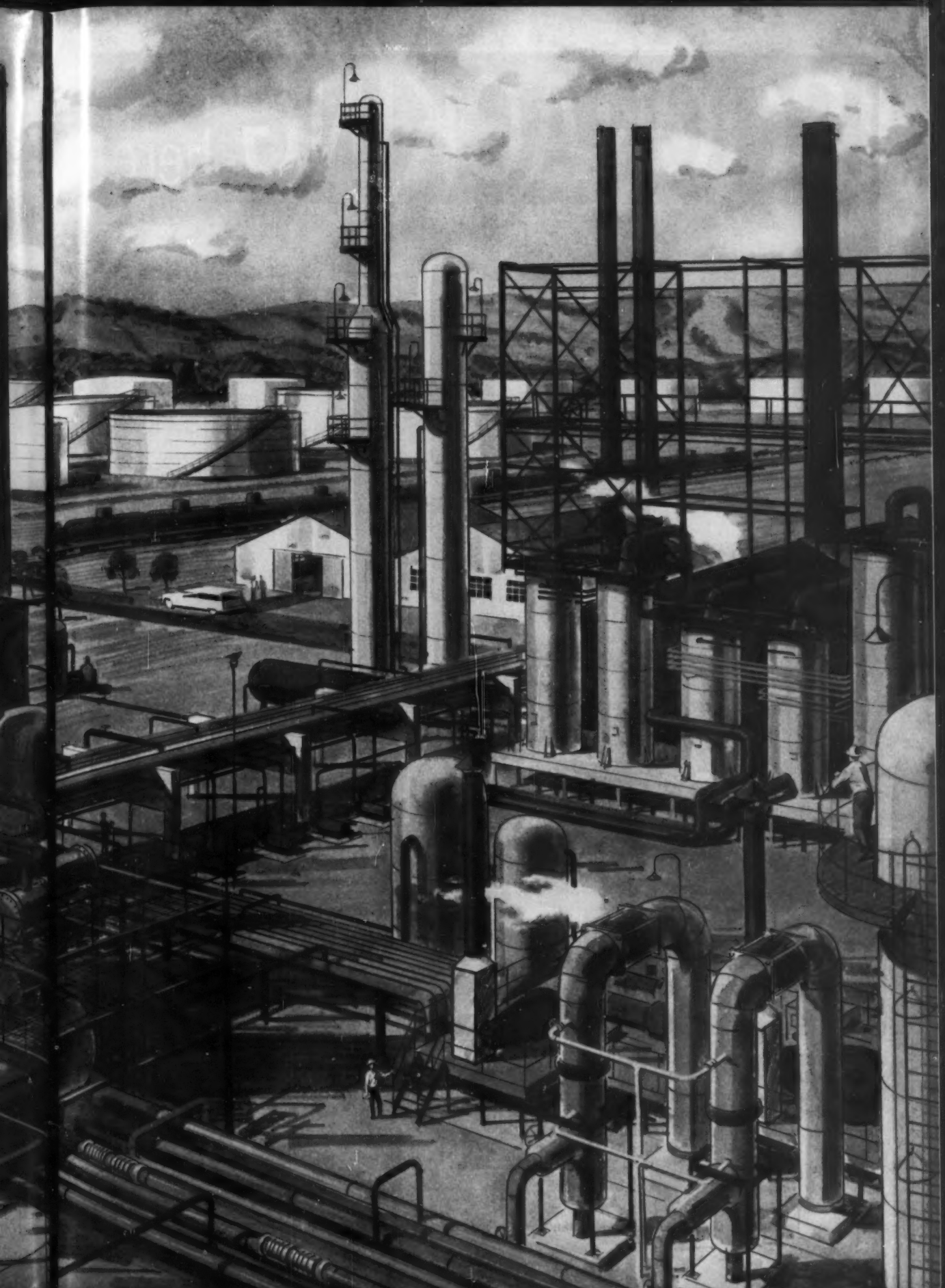

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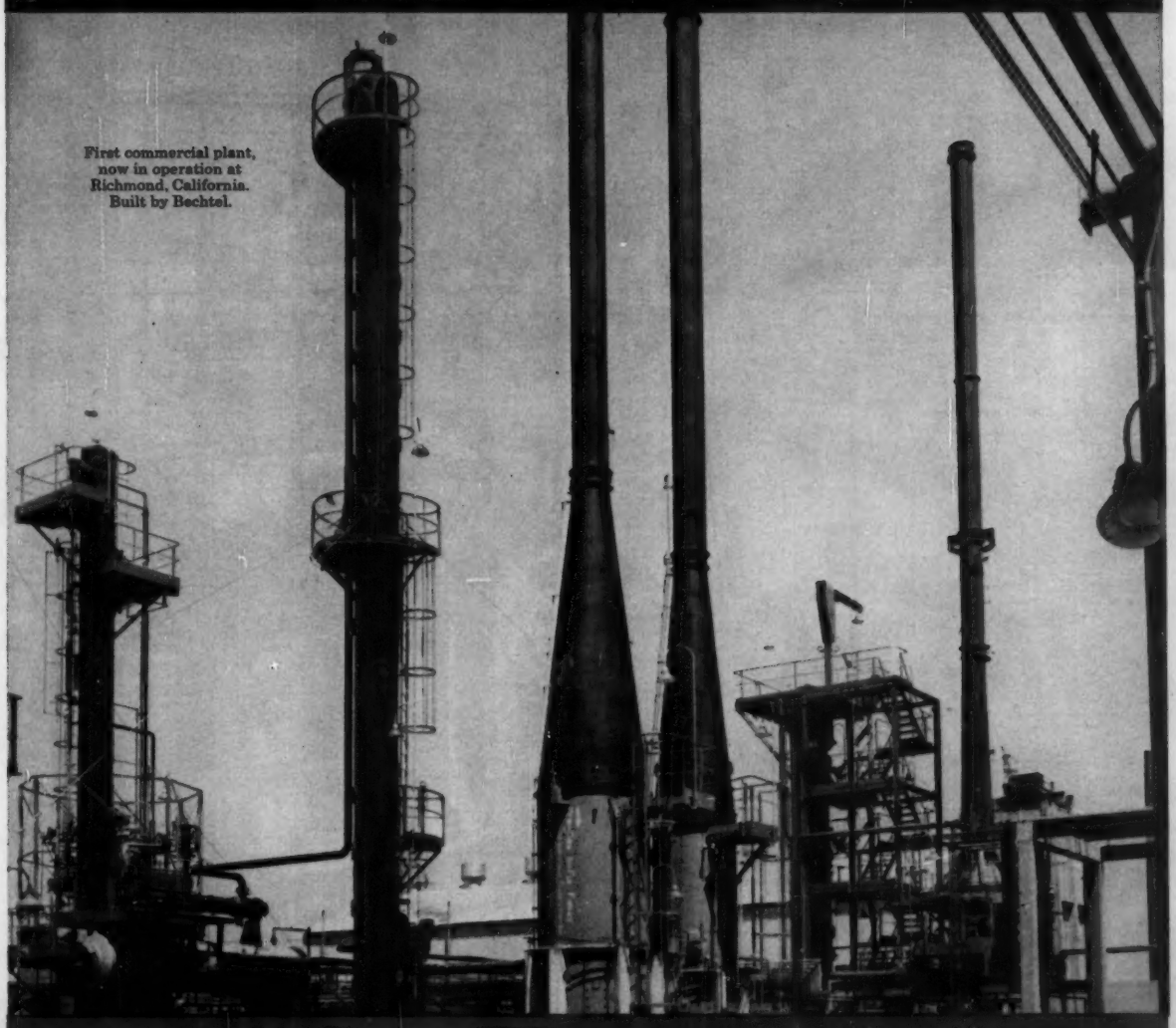

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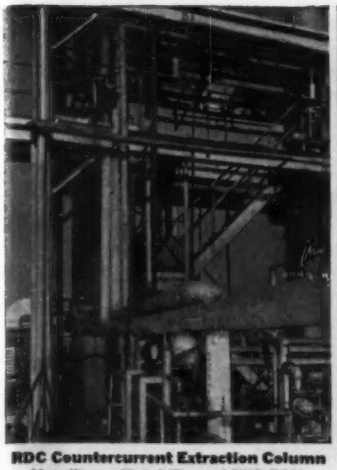

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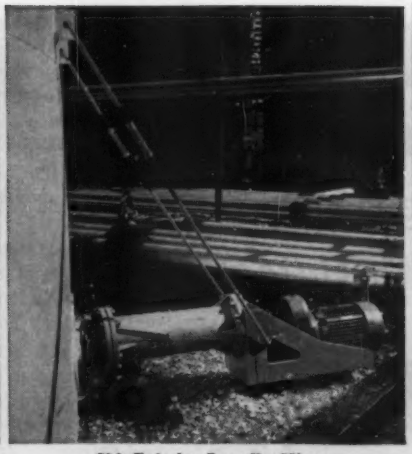

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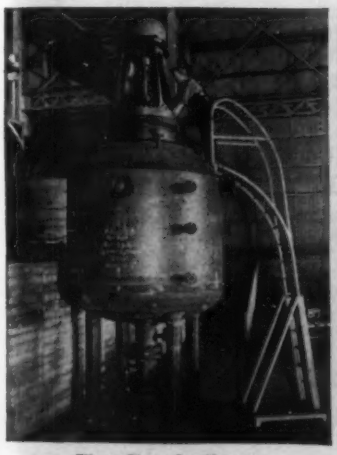

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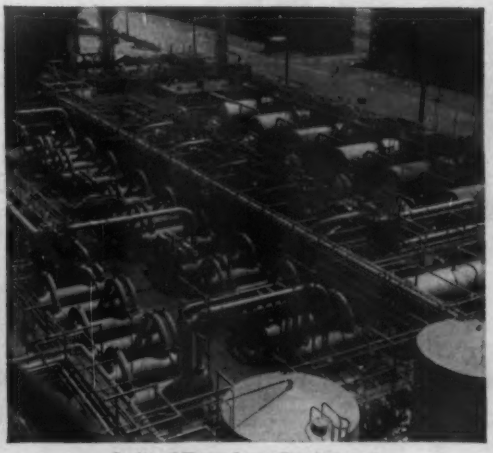

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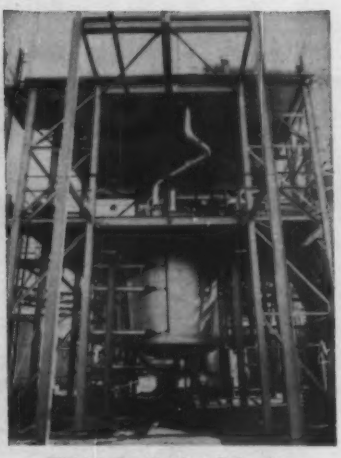

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Our quality control experts keep their eagle eyes on your fabricating work all along the way. They check materials and designs... all working, welding and testing operations. Come in and get acquainted with their exacting methods. Or write for Bulletins HE and CI.

A **The personal touch**—Our experienced, code-qualified welders are personally proud of the work they do. Each signs his welds with his own special code signature.

B **Come again**—Welded shells come back to the rolls for re-rolling that assures full roundness... smooth line-up with adjacent shell, head or tray.

C **Extra protection**—pressure-sensitive plastic film seals nozzle openings during shipment... keeps out dust, dirt, moisture. Hardboard cover prevents punctures.

D **Inside information**—The Magnaflux test... another way to inspect a welded seam... is frequently used to check critical pressure vessel welds at Downingtown.

Downingtown Iron Works, Inc.

151 Wallace Ave., Downingtown, Pennsylvania

division of **PRESSED STEEL TANK COMPANY** Milwaukee

Branch offices in principal cities

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

DOWNINGTOWN IRON WORKS INC. Hackney

For more data on advertised products, use Readers' Service Cards, last page.

A Dependable Source OF CHLORINE & CAUSTIC SODA...

...for Mid-South Industry

Manufacturers and Marketers of

CHLORINE
(Tank-Car Quantities Or One-Ton Containers)

and 50% - 73%
CAUSTIC SODA
(Tank-Car Or Tank-Truck Quantities)

Plant:
PINE BLUFF, ARK.

General Sales Office:
SLATTERY BLDG.
SHREVEPORT, LA.

PHONE: 2-2141, Ext. 495

ALC

ARKANSAS LOUISIANA CHEMICAL CORPORATION

A SUBSIDIARY OF ARKANSAS LOUISIANA GAS COMPANY

For more data on advertised products, use Readers' Service Cards, last page.

Improved Processing through Engineered Agitation

HOW IMPORTANT IS GOOD FLUID MIXING IN YOUR PROCESS?

REGARDLESS OF HOW SPECIALIZED your particular processing needs are, good mixing can be the difference between "run of the mill" and maximum yields.

NETTCO MIXERS ARE PROCESS-RATED for optimum performance. Your particular process requirement is fully evaluated. And—it costs no more to get the full benefit of Nettco's wealth of agitation technology and broad application experience. Then—from design and pilot test to full process conditions, standard components are precision teamed to provide you with a Nettco mixer to meet your most exacting conditions. If good fluid mixing is vital to your process, then Nettco Engineered Agitation is vital to *you!*

PUT NETTCO ENGINEERED AGITATION TO WORK FOR YOU. From a full line . . . side drive, tank top, portable or tripod and unique continuous pipeline mixers, NETTCO can provide the answers to a wide range of mixing problems. See your NETTCO representative listed in Chemical Engineering Catalog or Refinery Catalog, or write for Bulletin 582, New England Tank and Tower Co. 81 Tileston Street, Everett 49, Mass.

NETTCO

ENGINEERED AGITATION SPECIALISTS
EVERETT 49, MASSACHUSETTS

1. Paint blending with Nettco tank top mixers on 400 gallon portable tanks.
2. Nettco Flomix® in the continuous recycling of waste product to improve yield.
3. Variable speed pilot plant application of Nettco medium speed, propeller drive mixer.
4. Raw material batch blending with Nettco side drive mixer to assure uniformity.
5. 15 year old Nettco tank top mixer for synthetic rubber production with one of first double mechanical seals.

New from Hills-Mc Canna Company

Now...A Packless Metering Pump*

SEND for our new specification sheet with full data on the Masterline Packless Metering Pump #903

HILLS-McCANNA COMPANY
4614 West Touhy Ave. • Chicago 46, Ill.

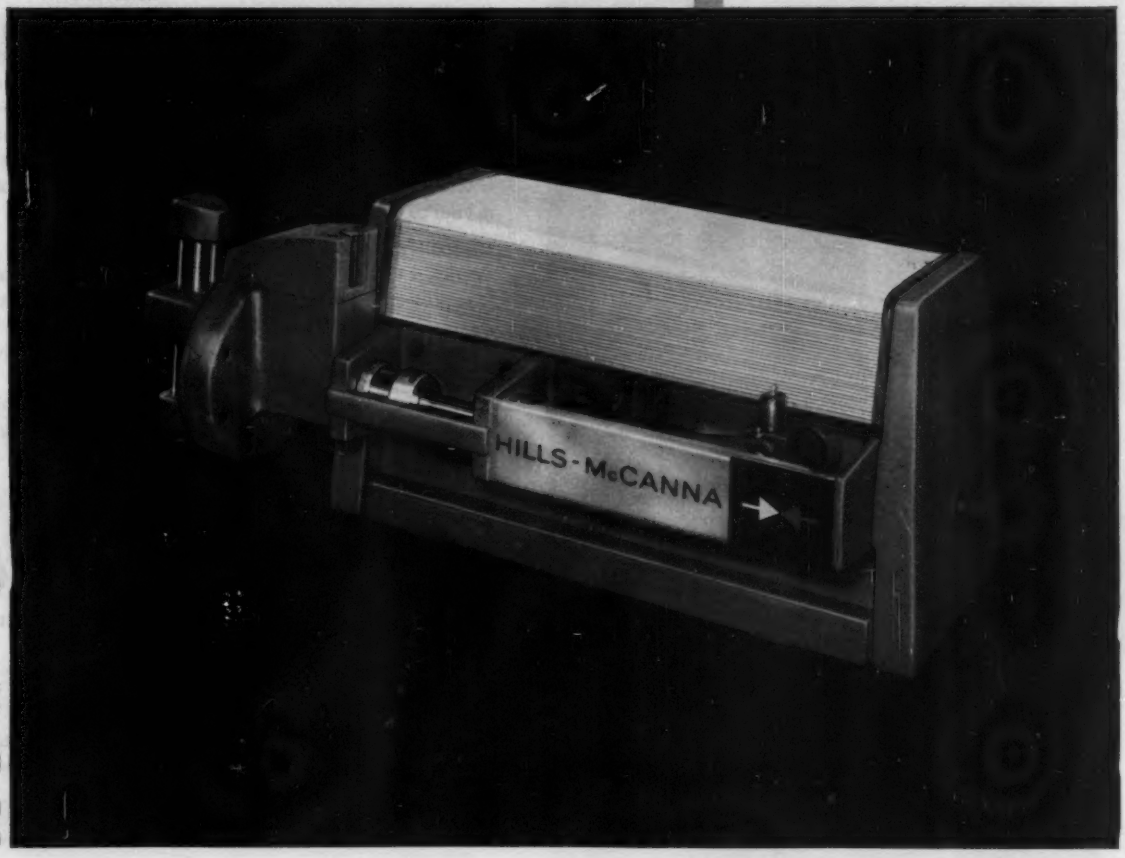
See us at the Chemical Show Nov. 30-Dec. 4
Booths 1173, 1174, 1175, 1176

ACCURACY! ECONOMY! DEPENDABILITY!
Proven Masterline Design!
Eliminate Costly Down Time and Maintenance with These Unique Features

- Packless Liquid End Construction
- Flooded Suction Not Required
- Constant Volumetric Displacement
- Design Eliminates Entrained Air On Hydraulic Side
- Built-in Safety Relief Valve
- Interchangeable With Standard Masterline Liquid Ends
- Plus All Regular Masterline Features: Simplified crank drive, pre-tested accuracy, sturdy construction, separate motor and speed reducer, adaptable for automatic or remote control . . . everything to insure dependable operation at lowest maintenance cost.

*PATS. APPL. FOR

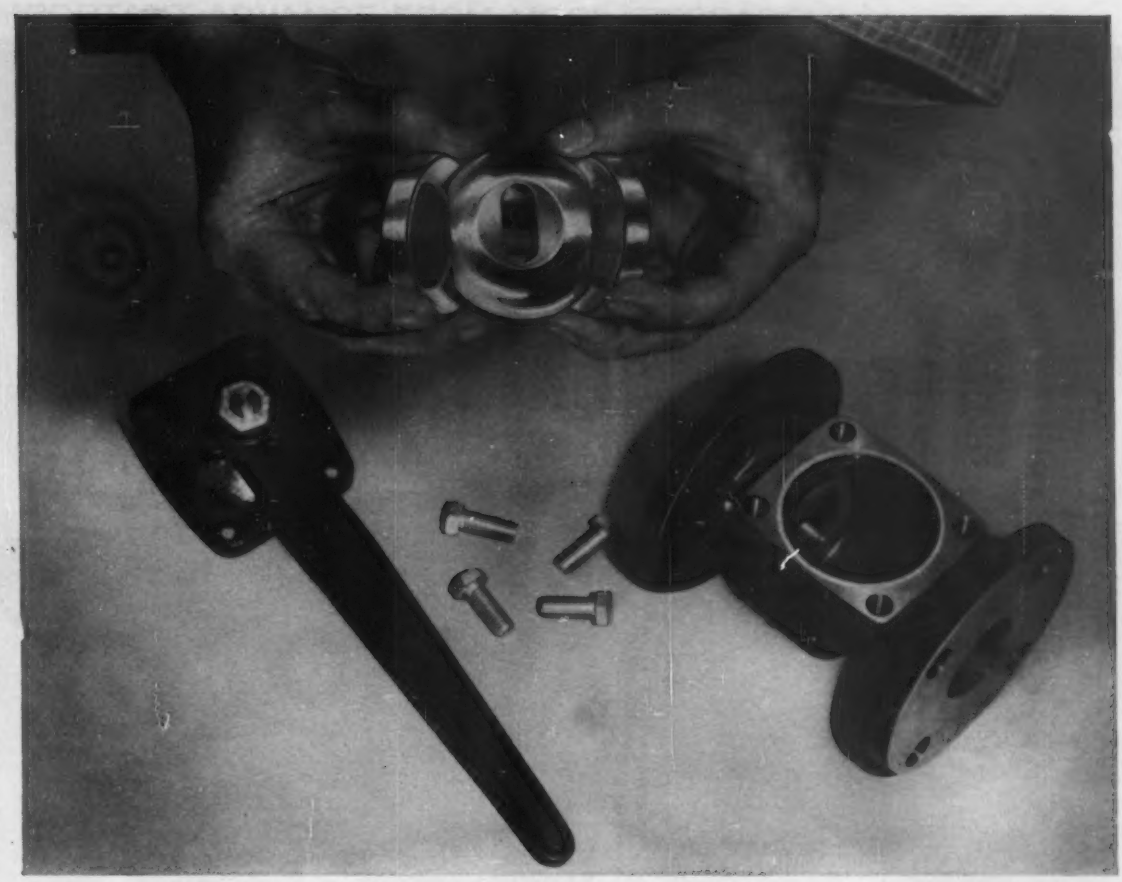
hills-mc canna company



New from Hills-Mc Canna Company

For more data on advertised products, use Readers' Service Cards, last page.

New from Hills-Mc Canna Company



Now a BALL VALVE* with all the features you've wanted

Thirty years of leadership in valve manufacture now brings you the Hills-McCanna Ball Valve! It offers every advanced feature to help you cut costs, step up production, reduce maintenance, and improve product quality.

- *Drip Tight Shut-Off*
- *Self Adjusting Seats For Extended Valve Life*
- *Top Entry For Easy In-Line Maintenance*
- *Quick Opening*
- *Minimum Pressure Drop*
- *Two-Way Flow*
- *Reduced Maintenance Cost*

*PATS. APPL. FOR

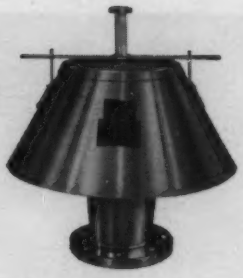
Save money!...solve valving problems ...send for free booklet describing the complete line of Hills-McCanna Ball Valves. Send for your copy of booklet #1100.

HILLS-McCANNA COMPANY
4614 West Touhy Ave. • Chicago 46, Ill.
See us at the Chemical Show Nov. 30 - Dec. 4, Booths 1173, 1174, 1175, 1176

hills-mc canna company

For more data on advertised products, use Readers' Service Cards, last page.

new **S&J** *Breather Valves*



Materially Reduce Storage Tank Vapor Loss

New Shand and Jurs model ST-9749 diaphragm-type breather valves are a major achievement in storage tank venting and vapor conservation.

They provide resistance to sticking, corrosion and freezing never before offered. In addition they require practically no maintenance feature non-wetting teflon-on-fiberglas diaphragms for maximum performance and longer life; completely eliminate critical drain holes or other areas that require continuous checking. Ruggedly built from aluminum and stainless steel, ST-9749 breather valves are lightweight, and already available in 4", 6", 8", and 10" sizes. Call your nearest S&J branch office or sales representative for Technical Bulletin 52D-ST-9749 Breather Valve.

SHAND AND JURS

GENERAL PRECISION EQUIPMENT CORPORATION GPE

2600 Eighth Street, Berkeley, California
Branch offices and representatives in principal cities

For more data on advertised products, use Readers' Service Cards, last page.

IMPORTANT ADVANCE FROM MOBIL RESEARCH...

1949
1959
Take this up with V.P.-Mfg.
Re: New Mobil TCC Unit
Points to cover:
1. We can cut mfg. costs + still get same through-put.
2. Over 17% more coke burn-off.
3. Almost 52% less plot area
4. Important—new unit requires 57% less steel, 40% less concrete, 48% less man hours to build.
Get more on this from Mobil.

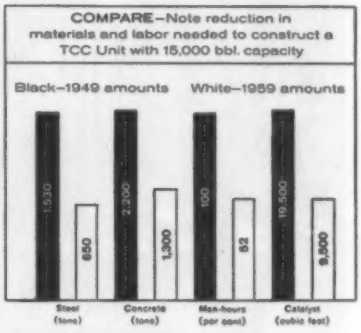
New TCC Units greatly reduce capital investment and operating costs

Since Socony Mobil developed the first Thermofor Catalytic Cracking unit during World War II, Mobil engineers have been steadily improving the basic TCC process and lowering construction costs. The figures speak for themselves—in the past ten years, steel requirements have been reduced by 57%, concrete by 40%, construction man-hours by 48%.

Not only are the new TCC units less expensive to build, operating costs are lower, thanks to Mobil's new bead catalyst, Heavy Durabead. Today's TCC yields more salable products from every barrel of crude oil.

There are many possible over-all processing procedures and cracking yield patterns for a given crude oil. Mobil is prepared to work with a TCC licensee to determine the best plan for his particular needs. Inquiries about TCC should be directed to Process Promotion Department, Socony Mobil Oil Company, Inc., 150 East 42nd Street, New York 17, N.Y.

Lower cost TCC Units . . . Another example of how Mobil research pays off by holding down the cost of gasoline.



Socony Mobil Oil Company

Leader in refining research

Mobil

For more data on advertised products, use Readers' Service Cards, last page.

company

"A ~~MAN~~ IS KNOWN BY THE

customers it

~~COMPANY HE~~ KEEPS"

Repeat orders are a continual source of pride at Pacific. They indicate the success of our pumps in satisfying the needs of our customers.

Since 1923, Pacific Pumps Inc. has been supplying dependable centrifugal pumps to refineries, chemical plants and similar process installations. Thousands of Pacific process pumps are now contributing to plant efficiency throughout the world.

Pump design and manufacture are not the only features of this enviable performance record. Pacific has a skilled service engineering staff. These men are available when needed... anytime, anywhere.

For complete information about Pacific centrifugal pumps for process service, write to:

PACIFIC PUMPS

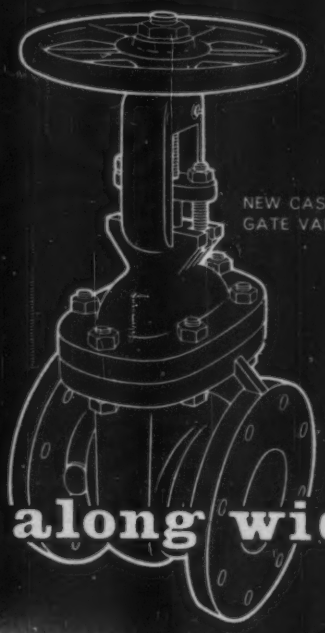
Inc... A Division of Dresser Industries, Inc.

HUNTINGTON PARK, CALIFORNIA

PACIFIC

Offices in all Principal Cities

NEW DOUBLE DISC VALVE



NEW CAST IRON GATE VALVE

NEW PARALLEL SLIDE VALVE

Thinking along wider lines . . .

. . . entering new fields, developing new ideas. That's the kind of look ahead thinking behind the Triangle Valve Company's range of some of the most advanced valve designs available. Today, the range includes Cast and Drop-Forged Carbon Steel, Stainless and Alloy Steel Valves and Cast Iron valves. New additions are light weight gate and "Y" valves. Triangle valves are used in many petrochemical plants, including corrosive and sub-zero services. Testing facilities for materials at low temperatures are available.

Full technical details and specifications from:

TRIANGLE VALVE CO. LTD.

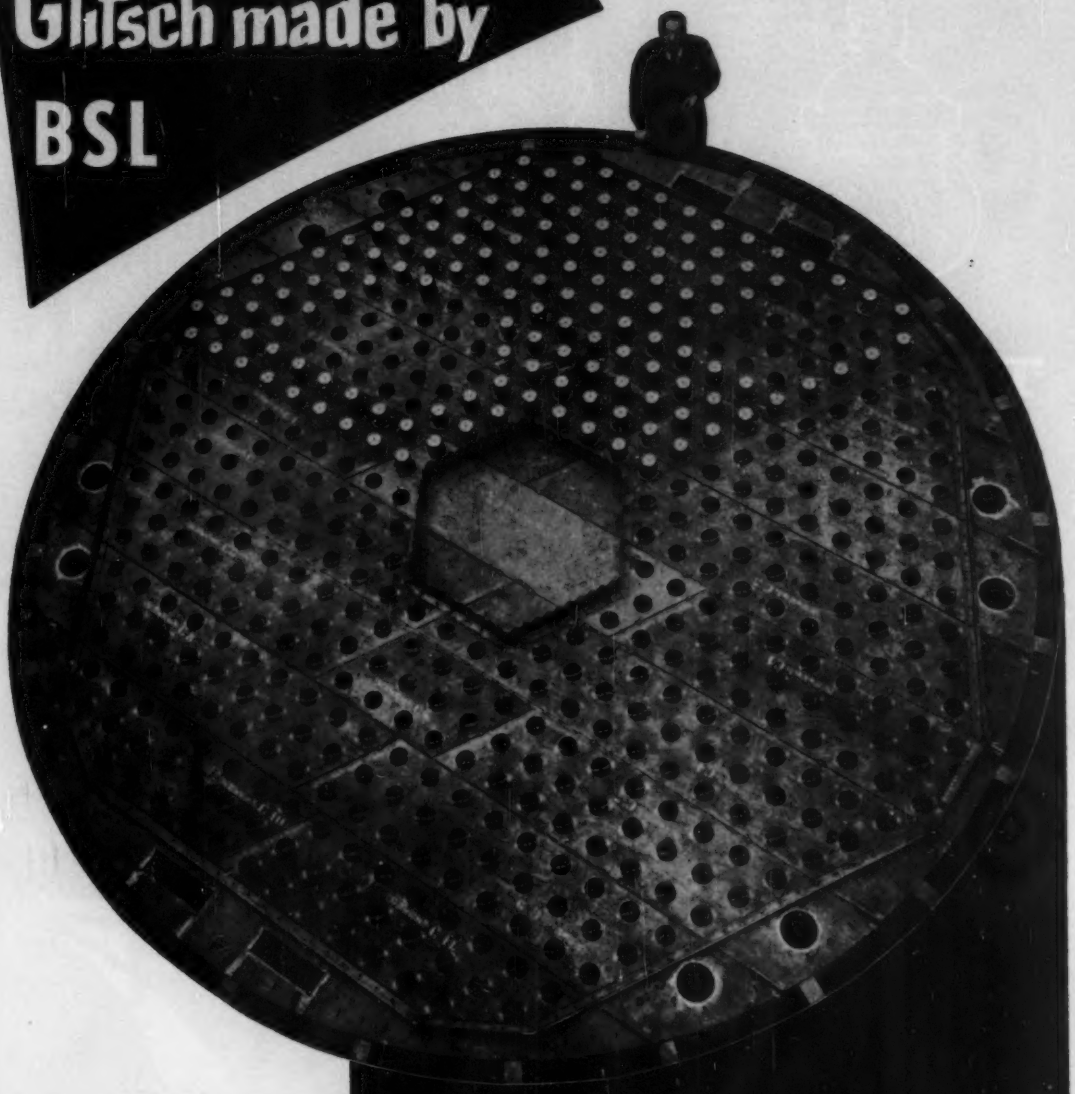
CANBERRA HOUSE, 315-7 REGENT ST. W.1.

Tel: LANGHAM 6526-7-8 Cables: Trivalon London Telex 24-100 Works: Lamberhead Green, Wigan, Lancs, England

Agents in: Holland · Belgium · Italy · W. Germany · Canada · Australia · Pakistan · Eire · Venezuela · France · Poland · Sweden · Finland · Norway

A wonderful American success in Europe :

Glitsch made by BSL

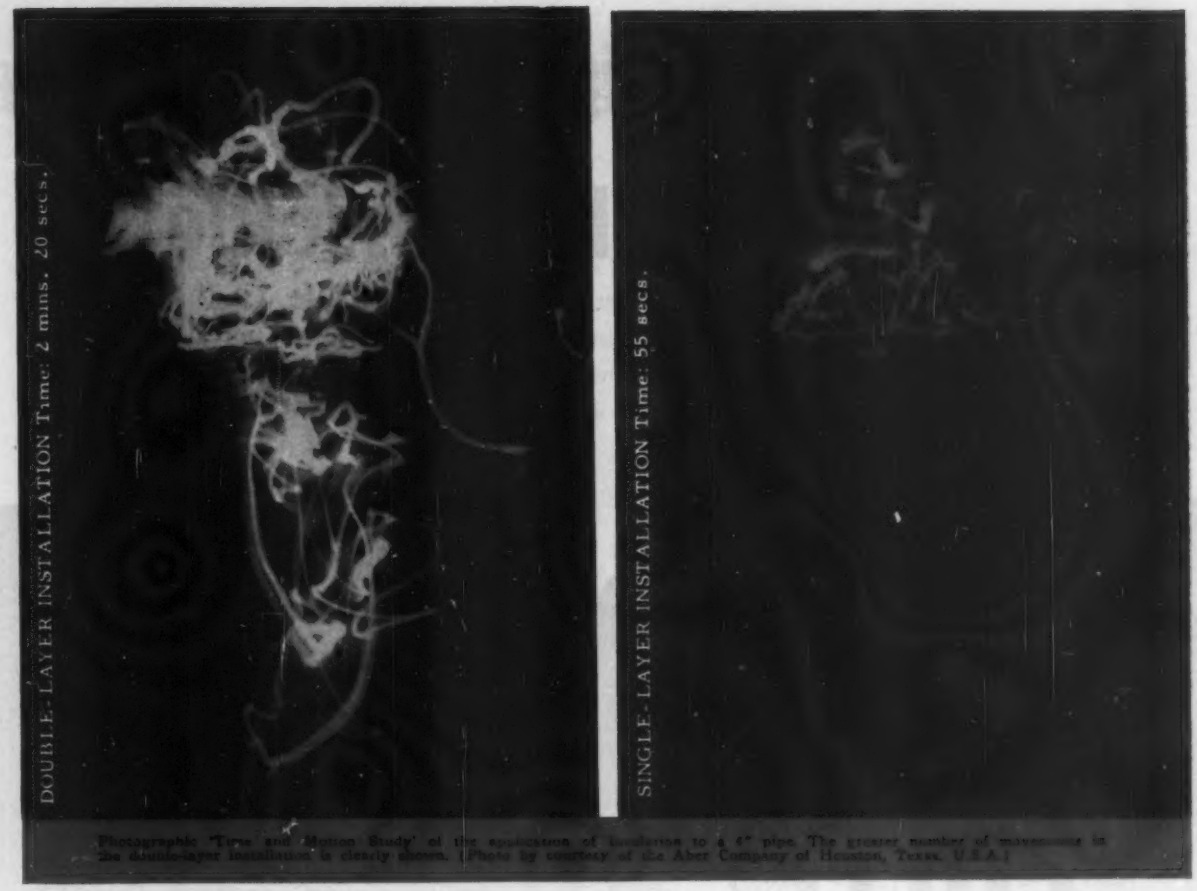


Bubble tray, fabricated from 12 chrome alloy steel with hexagonal type weir designed for à 22'-0" diameter tower.

BSL

BIGNIER, SCHMID-LAURENT

Stainless Steel Specialists
25, quai Marcel Boyer - Ivry (Seine) FRANCE
Téléphone : ITAlie 53-89
Cableaddress : BSL Ivrysurseine



Photographic 'Time and Motion Study' of the application of insulation to a 4" pipe. The greater number of movements in the double-layer installation is clearly shown. (Photo by courtesy of the Aber Company of Houston, Texas, U.S.A.)

One layer— Less work

CAPOSITE single-layer insulation

Insulation in a single layer! Caposite was developed by The Cape Asbestos Company to avoid the 'two-layer compromise' Caposite does it in one—saving considerably on installation time and costs. Caposite, the amosite asbestos insulation, is designed to withstand temperatures up to 1000° F. without loss of efficiency.

LOW JOINT LOSS

The fibrous edges of Caposite knit together at the joints giving a good heat seal and making staggered joints unnecessary.

EASY TO HANDLE

Its inherent strength makes it possible to handle Caposite in large sections for example at 2" thick for 30" n.p.s.—with very little damage and a further saving in installation costs.

CAPE

THE CAPE ASBESTOS COMPANY LIMITED 114 & 116 Park Street, London W. 1, Grosvenor 6022
Cables: Incorrupt London

Enquiries in Canada to: Cape Asbestos (Canada) Limited, 200 Bloor Street East, Toronto, Ontario.
U.S.A.: North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois.

TA 2548

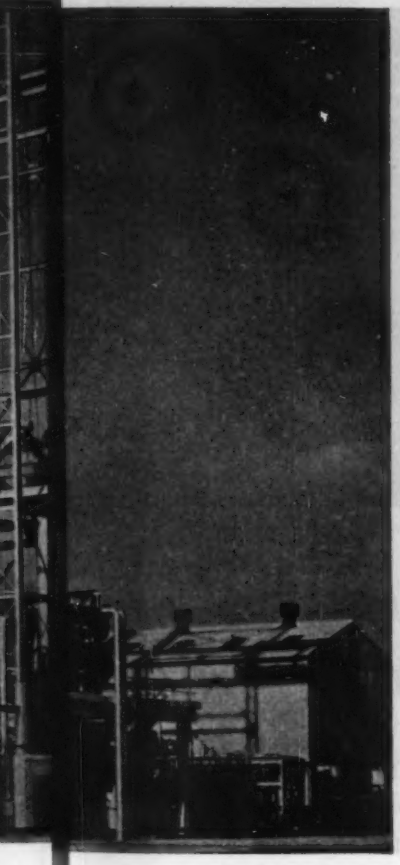
For more data on advertised products, use Readers' Service Cards, last page.

Outstanding performance

Shell Trickle Process

and economy with

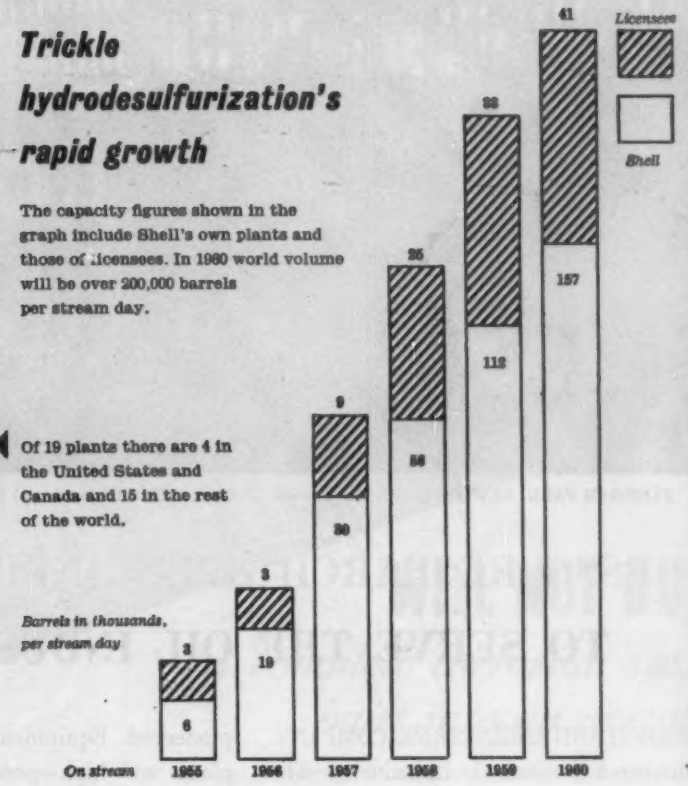
Substantial economies in both capital and operating costs result from relatively low hydrogen recycle rates with only part of the charge vaporized. Sulfur elimination of 85-90% from middle distillates is readily achieved. The process provides notably long runs between infrequent catalyst regenerations to initial activity. Although used commercially for the first time only in 1955, Shell's Trickle Hydrodesulfurization Process is now widely accepted in the industry.



Trickle hydrodesulfurization's rapid growth

The capacity figures shown in the graph include Shell's own plants and those of licensees. In 1960 world volume will be over 200,000 barrels per stream day.

Of 19 plants there are 4 in the United States and Canada and 15 in the rest of the world.



hydrodesulfurization

There is also available a Shell process for the vapor phase hydrodesulfurization of light fractions

Inquiries should be addressed, for plant locations in U.S. and Canada, to: Shell Development Company, 50 West 50th Street, New York 20, N.Y. Elsewhere to: Bataafse Internationale Petroleum Maatschappij N.V., 30 Carel van Bylandtlaan, The Hague, The Netherlands (P.O. Box 162).

For more data on advertised products, use Readers' Service Cards, last page.

FLORHAM PARK, NEW JERSEY, is the location of this new Esso Research and Engineering Center.

A NEW ESSO RESEARCH & ENGINEERING CENTER TO SERVE THE OIL INDUSTRY

The ESSO RESEARCH AND ENGINEERING COMPANY is proud to announce a new asset in its industry-wide process licensing program. Recently completed at Florham Park, New Jersey, is a new research and engineering center devoted to the development of improved refining processes and the design of modern, efficient refining and petrochemical units. The new facilities are ideal for development work on refining processes, an area of science in which this company pioneered. Equipment will feature automated pilot plants and high-speed electronic computers. As in the past, fully-developed processes will be licensed to the petroleum industry throughout the free world. The processes now available through the achievements of Esso Research and Engineering include Model IV Fluid Catalytic Cracking, Hydrofining, Powerforming, Fluid Coking, CAA Butadiene Extraction and many others.

ESSO RESEARCH AND ENGINEERING COMPANY
P. O. Box 243 Elizabeth, New Jersey

Your key to progress . . . an Esso Research process.

at last...

ABSOLUTE SAFETY

with

COMPLETE CORROSION RESISTANCE

is now available with

Haveg F.R.P. Armoring*

- Corrosion Resistance Inside and Out
- High Impact Resistance
- Low Maintenance Costs
- Elimination of Personnel Hazards

WILL NOT BURST!

a complete corrosion system built into an armored pipe.

*Fiberglass Reinforced Plastic

Here at last is the ultimate in resistance with the maximum in safety. Haveg FRP* Armoring now permits the use of Haveg pipe and fittings in many new applications. It is also available for use with fume duct, tanks, towers or wherever strength requirements have previously ruled out the use of plastic equipment. We invite your inquiries.

BOOTH 546 CHEMICAL SHOW—NEW YORK

HAVEG

HAVEG INDUSTRIES, INC.

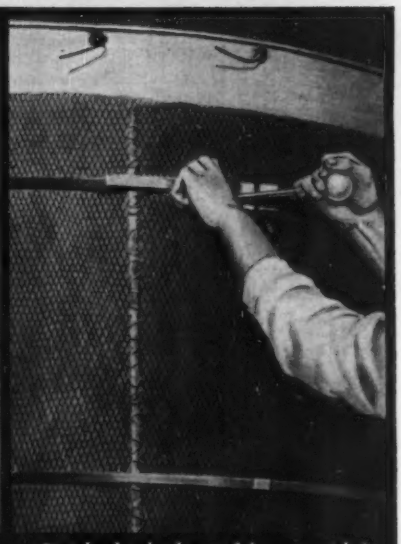
900 GREENBANK ROAD • WILMINGTON 8, DELAWARE

FACTORY FABRICATED TO RIGID SPECIFICATIONS!

EAGLE-PICHER BLANKET INSULATION

Ready for installation!

Easily conforms to surfaces!



Finished job, free of large voids!

- Copper bearing steel laths, bound by uniformly spaced soft-drawn galvanized tie wires, keep blankets firm but flexible.
- Eagle-Picher mineral wool evenly dispersed over entire insulating area of each blanket.
- Completely free of large voids usually found in field-made blankets where insulation is simply packed in place.
- Smooth edges butted tightly together eliminate cracks and loose joints.
- Quickly applied to flat or slightly curved surfaces of any large equipment—or cut to fit irregular areas.
- Maximum thermal efficiency at temperatures as high as 1200 F.

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

FREE SAMPLE!

Write today!

Eagle-Picher Blanket Insulation conforms to Commercial Standard CS-117-49.

Since 1843

EAGLE EP PICHER

EAGLE-PICHER

The Eagle-Picher Company • Dept. PR-11, Cincinnati 1, Ohio

(Member of Industrial Mineral Fiber Institute)

Protected by L. W. Blazecrete—this structure was virtually undamaged by 2 to 6 hours of *direct* flame exposure

Protected by Johns-Manville L. W. Blazecrete . . .

vital equipment is undamaged by 3 days of explosive fire!

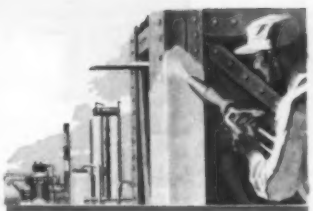
AFTER MORE than seventy hours of fire and explosion at one of the world's most modern thermofor catalytic plants, damage was estimated at nearly 8 million dollars.

Yet the flames didn't destroy the entire plant. Vital equipment, key structural members and control areas . . . made fire safe by Johns-Manville L. W. Blazecrete® . . . were virtually undamaged. This simple, low-cost protection paid for itself countless times over . . . helped get the refinery back on line many months sooner.

In your plant, too, Johns-Manville L. W. Blazecrete can save you money . . . for fire control and for lining high-temperature equipment.

A hydraulic-setting refractory—Johns-Manville L. W. Blazecrete is quickly, easily applied to equipment and structural members . . . and to linings of high-temperature equipment. For troweling, just mix L. W. Blazecrete with water as you'd mix ordinary concrete—then slap trowel in place. When gunned, L. W. Blazecrete adheres readily with a minimum of rebound loss. Whether used for fire protection or for linings—L. W. *Blazecrete lasts!*

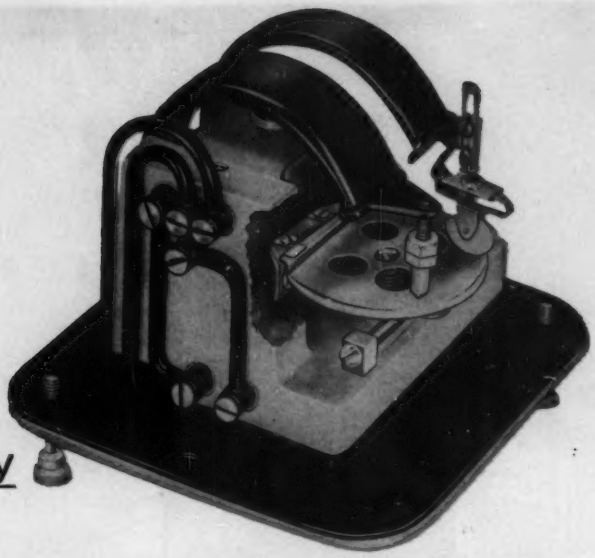
Find out more about this newest of fire protection ideas, and about the application of L. W. Blazecrete throughout the petroleum industry. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.



Gunned in place or slap troweled L. W. Blazecrete is the ideal material for refractory linings. It gives you an unusually strong, dense and homogeneous lining . . . ready for use within 24 hours.

JOHNS-MANVILLE

JOHNS MANVILLE JM PRODUCTS



NEW high sensitivity ASHCROFT PNEUMATIC TRANSMITTERS

lower costs...reduce maintenance ...provide tighter control

Ashcroft Non-Indicating Pneumatic Transmitters are made in pressure and temperature types, each in regular and short span. Operation is on low-pressure air: output range, 3-15 psi or 3-27 psi.

These new transmitters are designed around (1) a powerful, efficient relay with sensitivity high enough to operate controllers, and (2) a simple, dual Bourdon tube motion-balance system. High sensitivity permits the use of narrowest proportional band settings on controllers and allows instant controller response to deviations from set point. With a shorter transmission lag, automatic corrective action starts before the deviation becomes critical.

In manual control systems, these new Ashcroft Transmitters (teamed with suitable receivers) make it practical to operate boilers at the most efficient level. In wet processing operations, fractionating columns yield a purer product. Highly suppressed Ashcroft Short Span Transmitters are so sensitive they can "judge" entire control loops and detect any errors in the system.

Basically a 6" cube, lighter than most 8½" pressure gauges, these climate-proof Ashcroft Transmitters are simple to install in cramped locations, are most readily accessible for adjusting or service. Calibration is extremely easy, with linearity checking entirely eliminated. Most parts in all types in the line are interchangeable. Ask your nearby Ashcroft Gauge Distributor about the lower initial costs and other savings that follow when you install Ashcroft Non-Indicating Pneumatic Transmitters. Send for Bulletin 361.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

ASHCROFT PNEUMATIC TRANSMITTERS

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

BOEING BOMARC MISSILE---

ON TARGET...ON TIME...ON BUDGET

Designed to protect large areas against enemy bombers and missiles, the supersonic Boeing Bomarc air-defense missile is ready for operational service. Installation and check out of ground handling and ground support equipment at Otis Air Force Base is being performed by Catalytic, Engineers and Constructors. When specifications are rigid—or the need urgent—or when budgets are an important factor—consult

CATALYTIC
CONSTRUCTION COMPANY

Philadelphia 2, Pennsylvania
New York, New York
Baton Rouge, Louisiana
Toledo, Ohio

In Canada: Catalytic Construction of Canada, Limited; Sarnia, Ontario; Toronto, Ontario; Montreal, Quebec; Vancouver, B. C.

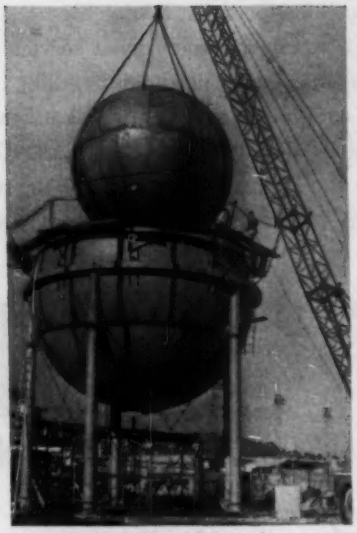
Catalytic *On-Time...On-Budget* Services for the metallurgical, chemical, petrochemical and oil refining industries: Project Analysis; Process Development; Process Design; Economic Studies; Engineering; Procurement; Construction.

For more data on advertised products, use Readers' Service Cards, last page.

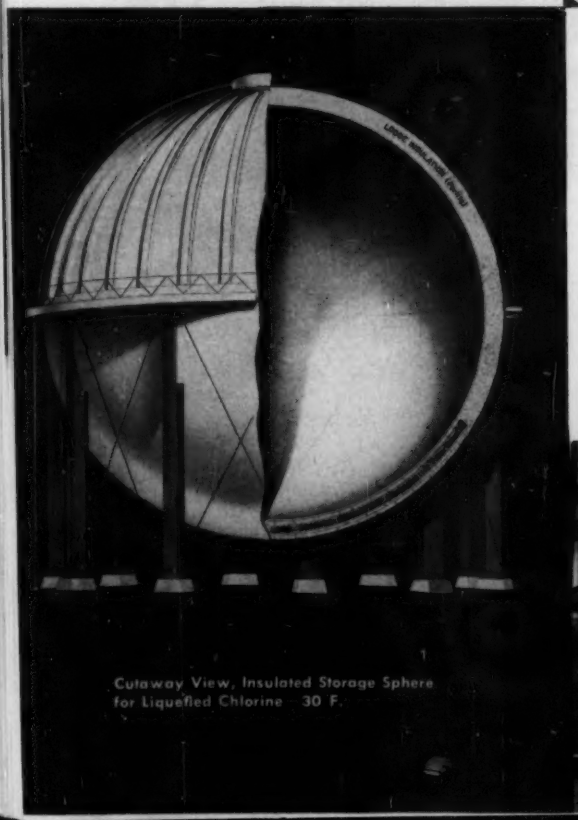
12 Vertical Pressure Vessels of T-1 Steel,
Each 63' x 11', Storing Air at 600 psia

PDM

ENGINEERS · FABRICATORS · CONTRACTORS



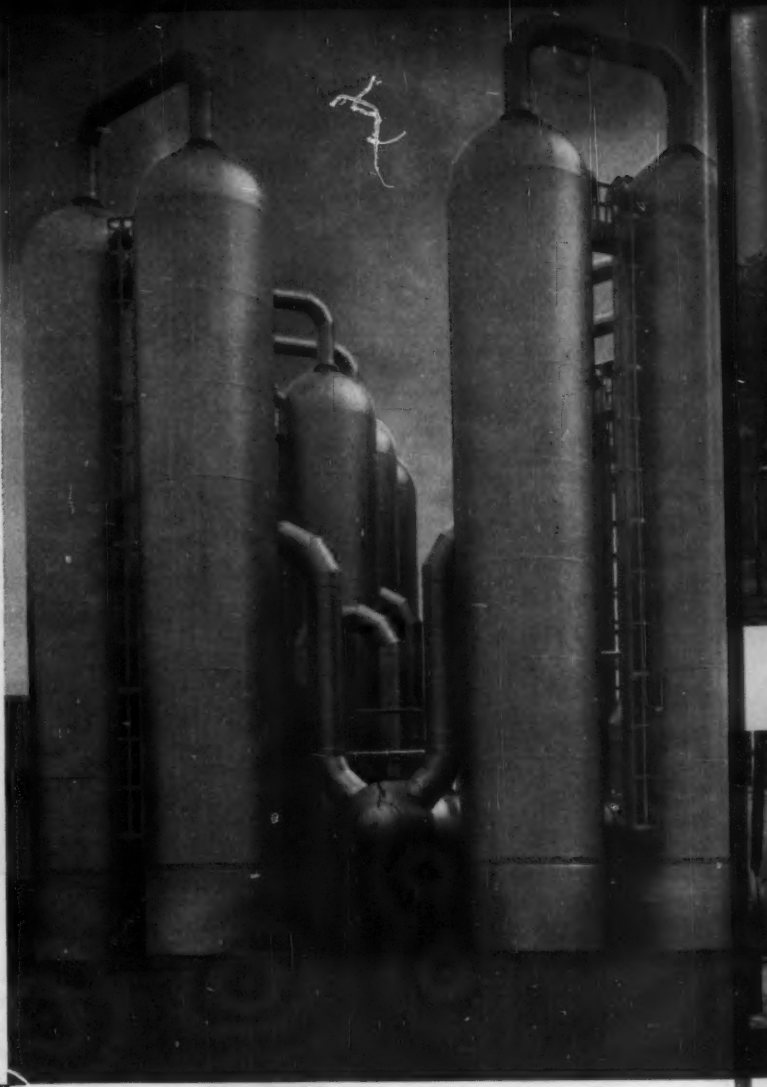
Double Insulated Spheres for
Low Temperature Storage



Cutaway View, Insulated Storage Sphere
for Liquefied Chlorine — 30 F.

TANKS, PRESSURE VESSELS
PLATE CONSTRUCTION
STRUCTURAL STEEL
. . . for the Petrochemical Industry

Vertical Reactor, 55' x 8'



Pit

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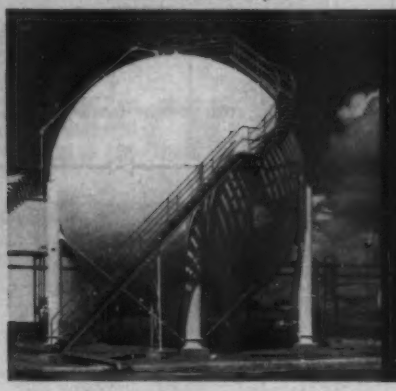
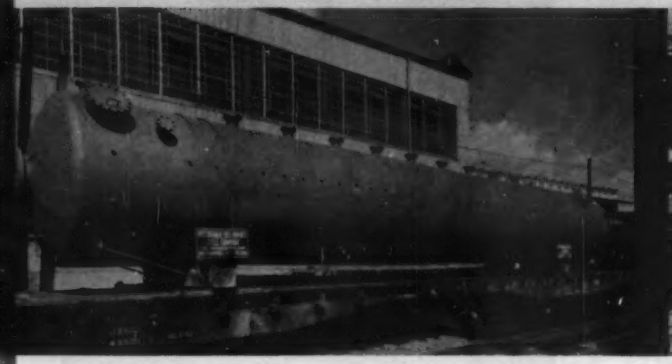
Elevated Water Storage for Compressor Stations

5000-Barrel Pressure Sphere



Flat Bottom Cone Roof Storage Tanks

Absorber Tower, 57' 9" x 8' 6".



5600 Tons of Radial Cone Bottom Mud Washers and Thickeners, Each 100' in Diameter.

Pittsburgh-Des Moines Steel Company

PRODUCTS—Tanks, A.P.I. • Tanks, floating roof • Tanks, special • Tanks, insulated • Tanks, lined • Elevated tanks • Pressure vessels • Spheres • Plate construction • Large diameter piping • Structural steel • Industrial type buildings • Steel bridges

MATERIALS—Pittsburgh-Des Moines builds tanks, vessels and structures of steel, stainless steel, stainless clad steel, alloys and aluminum

SERVICES—Pittsburgh-Des Moines' complete service to the client includes *design*, to accomplish required objectives—*selection of material*, proper for service needs—*preparation of detailed drawings*—*fabrication*—and *delivery* and *erection or installation*. Included also are the design, procurement and installation of all associated items such as foundations, pumps, compressors, coolers, dryers, piping, insulation, refrigeration, controls, electric wiring, etc.

SCOPE—The range of PDM product manufacture includes tanks, vessels and plate construction of plates from ⅛" to 13" thick, shop-built vessels and structures, weighing up to 100 tons, and field-assembled vessels or structures of any size.

ENGINEERING—The development, design and coordination required for successful completion of the widely varied work of the Company are functions of our Engineering and Research facilities. Our engineering groups comprise men outstanding in creative engineering, structural design, stress analysis, metallurgy, welding techniques, physics, gas dynamics, heat exchange, mechanical, electrical and control work.

RESEARCH—PDM Research investigates problems encountered in engineering for which known data or criteria are not available. A large part of our research is devoted to product improvement and the solution of new problems created by unusual and advanced projects undertaken. Materials and conditions for storing various chemical substances, protective coatings for structures and vessels, heat exchange rates and insulation values, etc., are tested and evaluated. From these studies and much related work has come a wealth of data advancing our ablity to serve our customers with better structures at the lowest levels of cost.

INQUIRIES—We invite your inquiries and the opportunity to quote on steel tanks, platework and structural steel fabrication of every type, including design studies, research, engineering, and erection. Consultations will gladly be arranged at your convenience, without obligation of any kind. Write, telephone or wire our nearest office.

Pittsburgh-Des Moines Steel Company

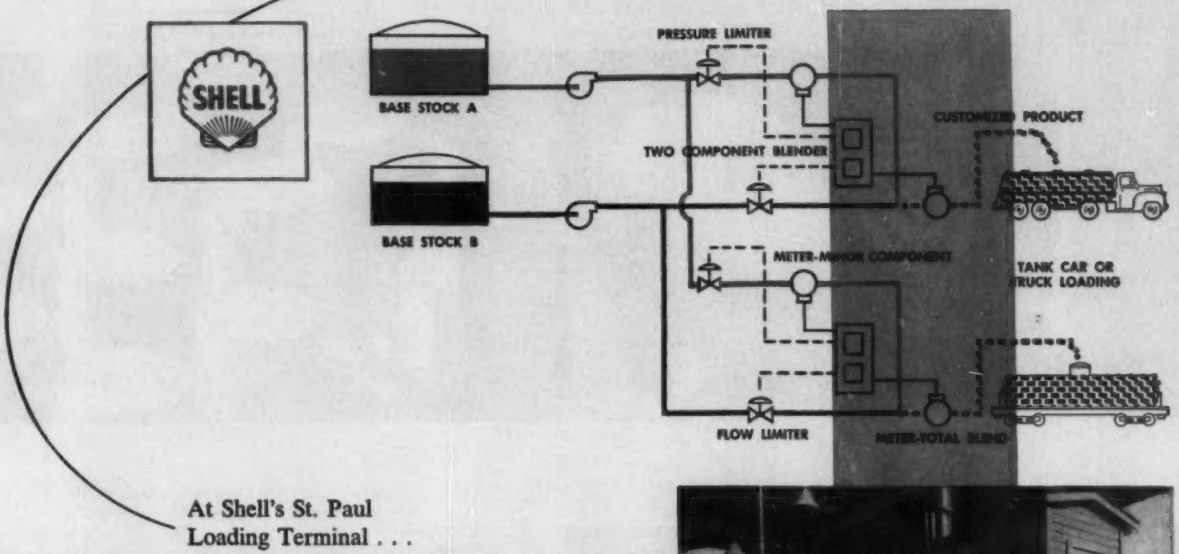
Plants at PITTSBURGH, BALTIMORE, DES MOINES, SANTA CLARA, FRESNO, and STOCKTON, CALIF.

Sales Offices at:

PITTSBURGH (25)------3482 Neville Island
BALTIMORE (26)-------Curtis Bay Station
NEWARK (2)------1763 Military Park Bldg.
CHICAGO (3) 686 First National Bank Bldg.
EL MONTE, CAL.---------P. O. Box 2012
ATLANTA (5)--361 E. Paces Ferry Rd., N.E.
DES MOINES (8)--------983 Tuttle Street
DALLAS (1)---Suite 1787, Southland Center
SEATTLE (1)-------Suite 390, 500 Wall St.
SANTA CLARA, CAL.------689 Alviso Road
DENVER (2)----323 Railway Exchange Bldg.

POSITIVE CONTROL OF MATERIALS IN MOTION

METERS
FEEDERS
CONTROLS



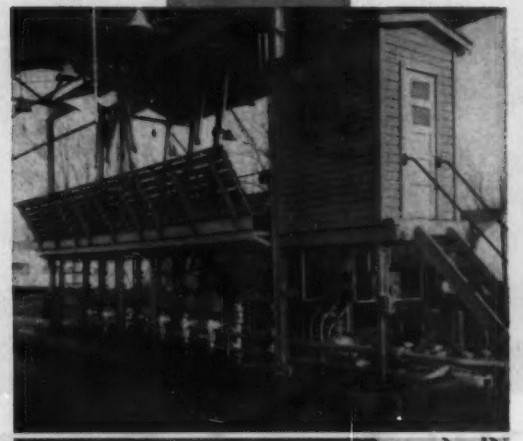
At Shell's St. Paul
Loading Terminal . . .

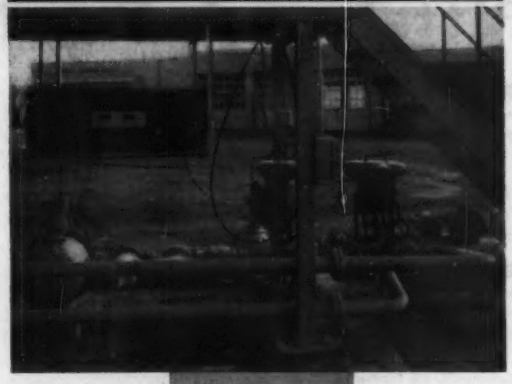
FLICK-OF-FINGER SOLVENT FORMULA CHANGES!

With *Proportioneers* Blenders,

a flick of a dial and any two base stocks can be specification-blended on the spot . . . without the need for intermediate tankage! Costly time losses at the loading rack are completely eliminated. Any blend of two base stocks can be duplicated with complete uniformity . . . any number of times . . . at formulation ranges from 5% to 95% for either component to suit exact customer requirements.

At this Shell installation, like those at Wagner's Point, Md. and Fall River, Mass., Proportioneers in-line TC blending systems custom-blend solvents *directly* to truck or tank car . . . providing quick-change formula flexibility that speeds terminal activity. Proportioneers systems are totally integrated and enclosed . . . designed for completely automatic, safe, accurate handling of petroleum products. Percentage ratios are easily and quickly set . . . operation is "fail-safe" under all conditions. Written *guaranteed accuracy!*





Write for complete data . . . to
B-I-F Industries, Inc.
Dept. P. 412 Harris Avenue,
Providence 1, Rhode Island

B-I-F

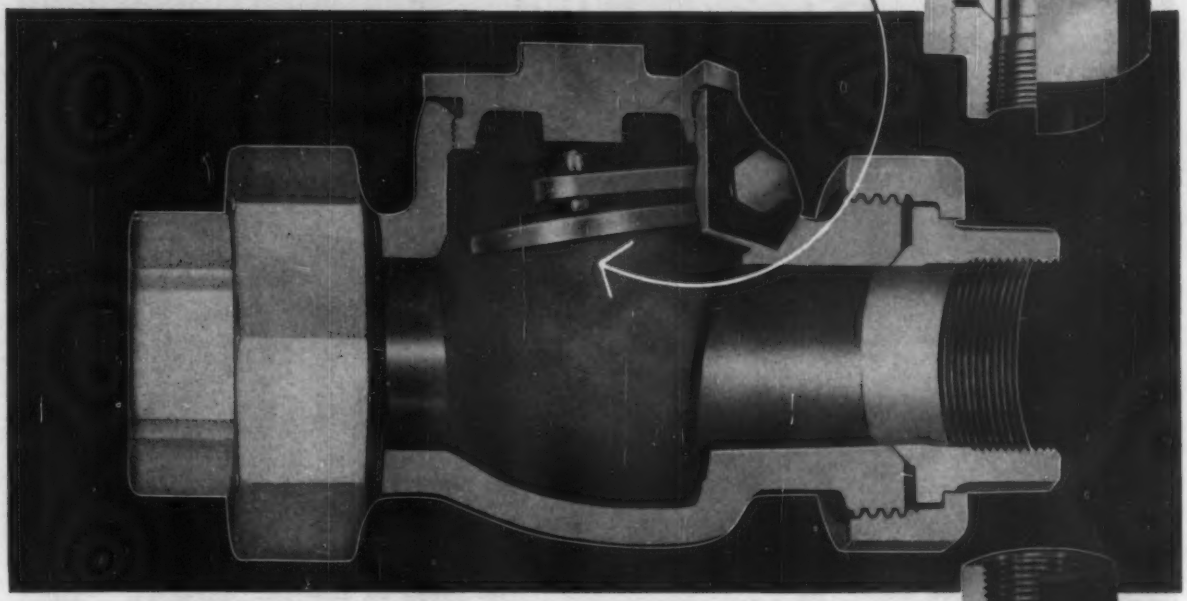
B-I-F INDUSTRIES

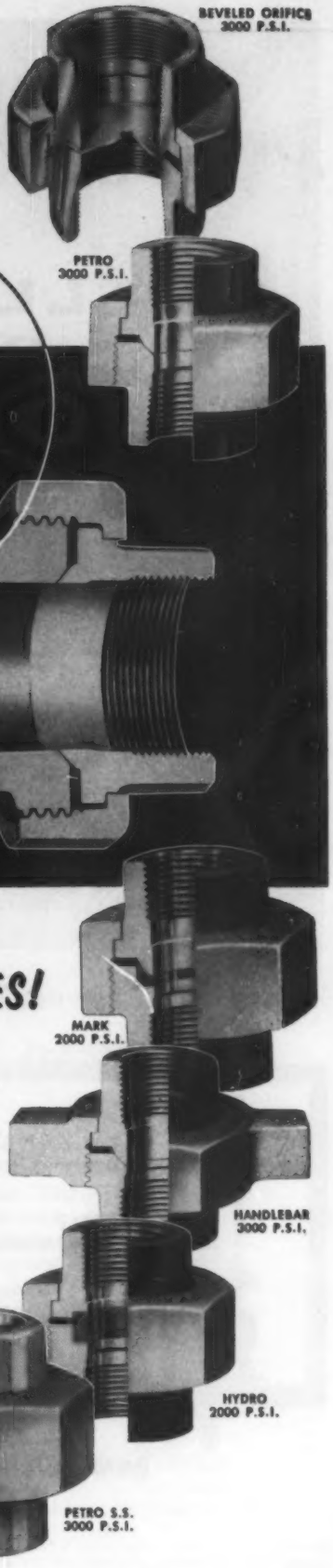
BUILDERS-PROVIDENCE · PROPORTIONEERS · OMEGA

For more data on advertised products, use Readers' Service Cards, last page.

Brand New!

CLAYTON MARK *full opening* UNION CHECK VALVE





ALLOWS FREE PASSAGE OF PRODUCT SEPARATING OR LINE CLEANING DEVICES!

- Full Opening Poppet
- Removable Stem
- Metal to Metal Seats
- Fits 2" Diameter Pipe
- Rated 500 P.S.I.—W.O.G.

New *full opening* Union Check Valve joins the family of Clayton Mark Unions . . . bringing to industry a top entry swing-check valve with superior features . . . offers many advantages especially for liquid processing. A pioneer in the manufacture of valves and steel unions, Clayton Mark has developed a complete line that serves as the industry's "yardstick" of quality and performance. When you want the best—specify C.M.!

Feature for feature CM Unions are superior!

CLAYTON MARK & COMPANY

1900 Dempster Street • Evanston, Illinois

stop-off high pressure 4", 6" and 8" lines Safely

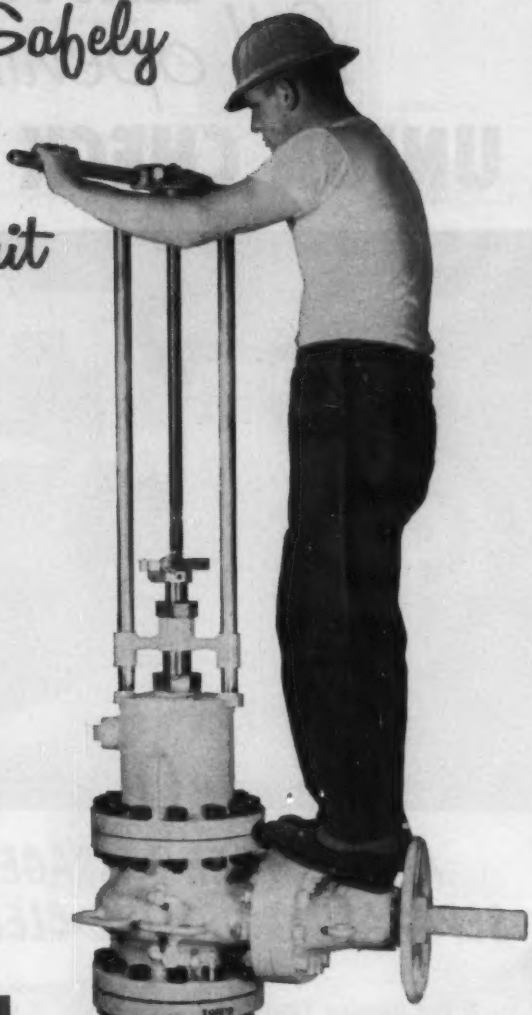
NEW MUELLER® Line Stopper Unit

No. 3SW-500

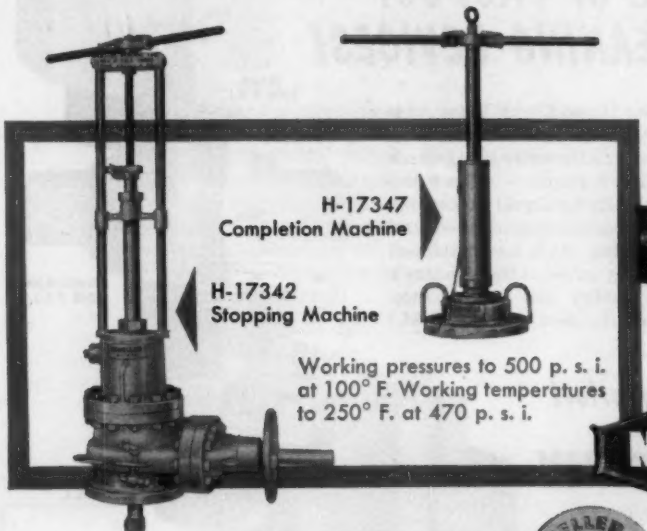
Now—Mueller Co. has developed a line stopper unit to give quick, effective, economical stop-offs of 4", 6" and 8" lines *under pressures up to 500 p. s. i.*

Unit No. 3SW-500 includes the necessary machines and equipment to make two-stop-offs at once. Convenient, built-in by-pass connection makes it easy to set up a temporary by-pass line to maintain flow in the line. Relocations, tie-ins and repairs can then be made in complete safety.

These design features are typical of the attention to detail in research, design and engineering that becomes a part of every Mueller product.



Making a stop-off on a 6" line with a Mueller H-17342 Stopping Machine.

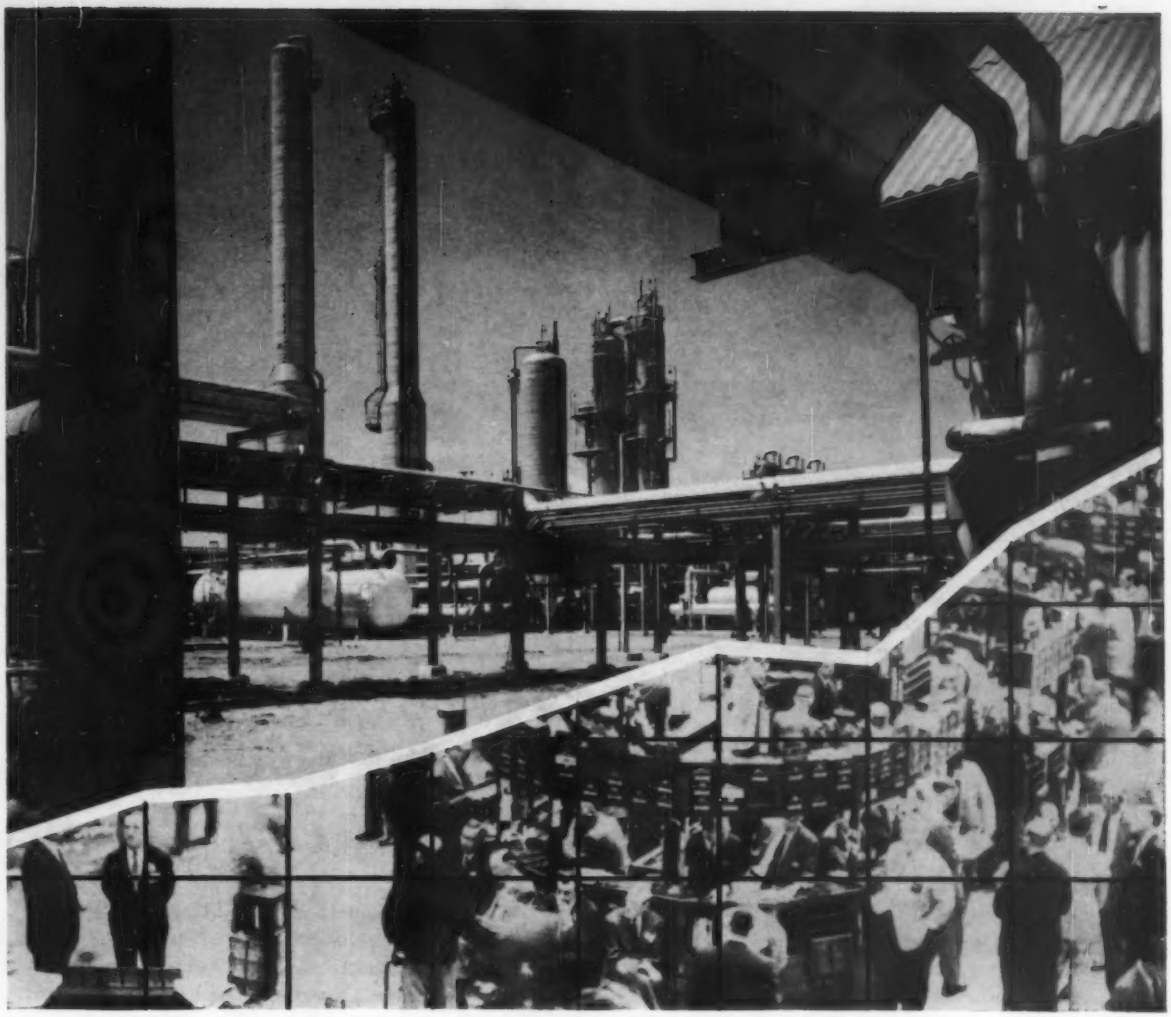


Working pressures to 500 p. s. i. at 100° F. Working temperatures to 250° F. at 470 p. s. i.

NO-BLO®

MUELLER CO. **DECATUR, ILL.**

Factories at: Decatur, Chattanooga, Los Angeles; In Canada: Mueller, Limited, Sarnia, Ontario



Pritchard's solution to volume hydrocarbon recovery...

with, above all, GOOD FINANCIAL DESIGN

One of the largest petro-chemical plants ever built – National Petro-Chemical Corporation's Tuscola plant–has changed an entire industry's thinking about hydrocarbon recovery. Designed and built by J. F. Pritchard & Company, Tuscola extracts ethane, propane and butane from natural gas using an oil absorption cycle in the extraction section shown above. The result: 50% more ethane per dollar invested than with low temperature condensation plants, and appreciably lower operating costs. Tuscola has set new profit potentials for the fuller utilization of natural gas.

Creative engineering as exemplified by Tuscola is only part of Pritchard's over-all approach to plant construction. Pritchard services – ranging from economic surveys to delivery of a turnkey job – all focus on one main consideration: good financial design. Engineering and construction are our long suits – but profitable, on-stream operation is the basis of our reputation.

If you are planning new construction in the gas, petroleum, petro-chemical or power fields, give us an opportunity to show you how good financial design can work for you.

PROFITABLE FACILITIES THROUGH GOOD FINANCIAL DESIGN

J.F. Pritchard & Co.

ENGINEERS • CONSTRUCTORS

Dept. 409, 4825 Roanoke Parkway, Kansas City 12, Mo.

OFFICES IN CHICAGO, HOUSTON, PITTSBURGH, NEW YORK

SERVING THE GAS, POWER, PETROLEUM AND CHEMICAL INDUSTRIES

For more data on advertised products, use Readers' Service Cards, last page.

NEW!

W-K-M's *Pressure Sealing* GATE VALVE

THIS BOLD ADVANCE IN VALVE DESIGN

Assures:

- ***Positive Seal***
- ***Efficient Operation***
- ***Superior Performance***

Floating Seats Give Perfect Seal. Each seat in W-K-M's *Pressure Sealing* Gate Valve consists of two kinds of rubber, formulated to W-K-M's specifications, molded to a hardened steel insert. There is a full bore opening, the same diameter as the port, through the insert.

Soft rubber, for sealing, is on the back side of each seat. Tougher, abrasive-resistant rubber is on the front or gate side. The steel insert is ringed with holes. Pressure forces the soft rubber through these holes, reinforcing the tough rubber and compensating for any wear.

Line Pressure Seals the Seats. In the closed position, the gate forms a primary seal with the raised ring of tough, firm rubber on the the face of each seat. As the line pressure is applied to the valve, the gate is forced against the rubber ring on the downstream seat and compresses it until the gate rests against the hardened steel insert. This provides a tight seal between the gate and the rubber on the face of the seat, and a secondary metal-to-metal seal. The action also forces the soft rubber on the back of the seat tightly into its recess and prevents any downstream flow at this point. The result: a bubble-tight downstream seal.

The upstream seal is caused by line pressure forcing its way into the seat recess behind the upstream seat, moving it against the gate. This pressure is sufficient to achieve a positive seal between the gate and the ring of tough rubber on the face of the seat. At the same time, the raised rim of soft rubber on the back of the seat forms a tight seal with the seat recess.

These double-action floating seats provide tight, positive seals — both upstream and downstream.

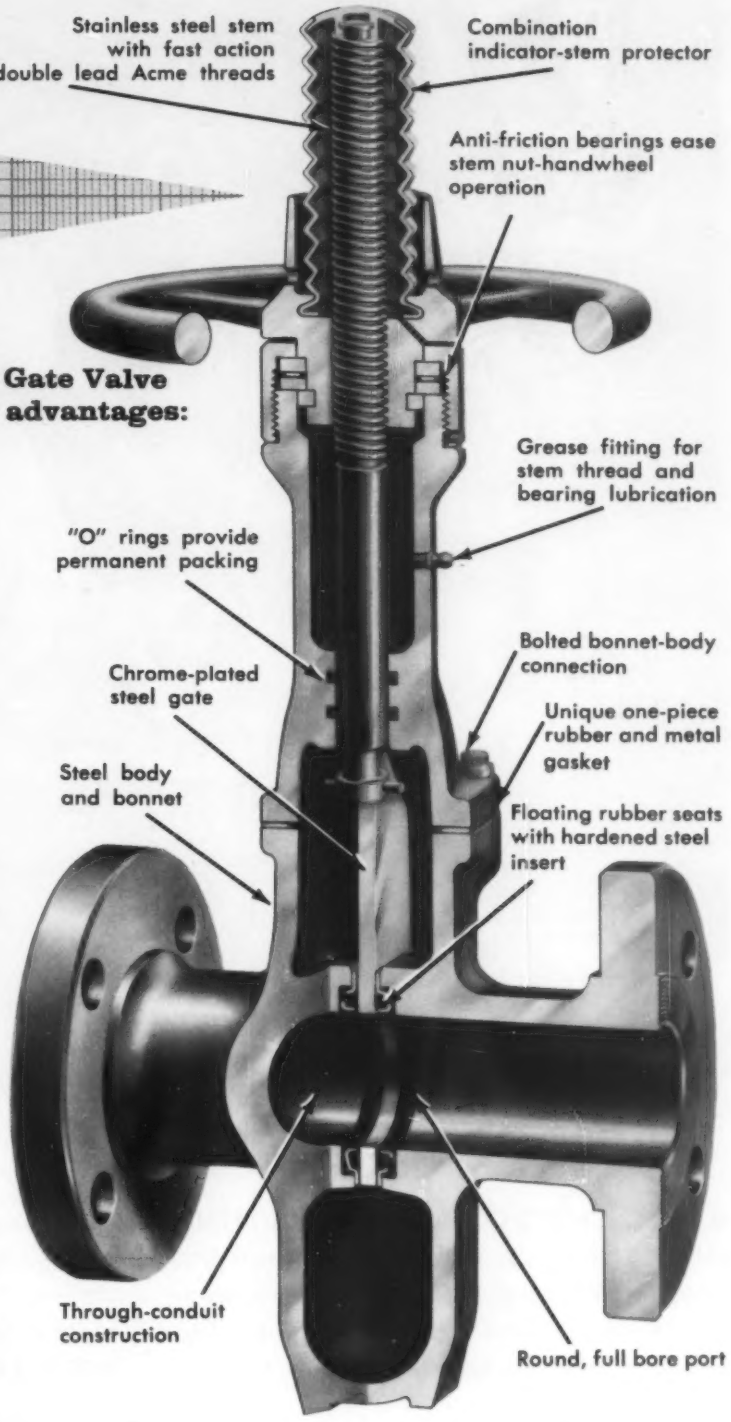
Change Seats in Minutes — On the Line! You can change the seats in W-K-M's *Pressure Sealing* Gate Valve *on the line*. The only tools needed are a wrench to loosen the body bolts, and a pair of pliers.

Important Safety Feature: This valve has been designed to automatically relieve excessive body pressure caused by thermal expansion. The excess pressure forces the upstream seat away from the gate, allowing it to bleed into the line.

Additional Advantages: The full bore, through-conduit gate construction provides a perfectly smooth bore through the valve, eliminating pockets or cavities in which foreign matter might accumulate. Result: perfectly smooth flow with no more turbulence or pressure drop than through an equal length of pipe.

W-K-M's *Pressure Sealing* Gate Valve is a two-way valve and may be installed with the pressure on either side. It is especially well suited for block and bleed service since it seals positively both upstream and downstream. The body may be bled of pressure with the gate in either the fully open or fully closed position.

ANOTHER OUTSTANDING PRODUCT OF **W-K-M's** *Creative Engineering*


Stainless steel stem with fast action double lead Acme threads
Combination indicator-stem protector
Anti-friction bearings ease stem nut-handwheel operation
Grease fitting for stem thread and bearing lubrication
"O" rings provide permanent packing
Bolted bonnet-body connection
Chrome-plated steel gate
Unique one-piece rubber and metal gasket
Steel body and bonnet
Floating rubber seats with hardened steel insert
Through-conduit construction
Round, full bore port

W-K-M's *Pressure Sealing* Gate Valve gives you all these operating advantages:

- **Tight seal both up and downstream in open and closed position**
- **Full bore, through-conduit**
- **Seats fully protected from abrasive action of lading**
- **Non-lubricated**
- **Seats automatically adjust for wear**
- **Automatic relief of excessive body pressure**
- **Ideal for abrasive ladings, light gases, volatile liquids up to 250° F.**
- **Easy to overhaul on the line**

Tested and Proved in the Toughest Services. Enthusiastic, completely favorable user reports affirm the superior quality and effortless operation of W-K-M's new *Pressure Sealing* Gate Valve. "Handles all the sludge in a gas blowout line easily – works better than any valve we've used," states a petroleum engineer. A foreman says, " . . . easiest operating valve I ever saw . . . smoothest working valve made." Similar reports covering many other services are in W-K-M's engineering test data files.

One of the Most Versatile Valves Ever Produced. W-K-M's *Pressure Sealing* Gate Valve is extremely versatile – can handle almost any low pressure job. It's designed for pressures up to 720 psi (cwp) and temperatures up to 250° F.

ASA 150 lb. (275 cwp) and ASA 300 lb. (720 cwp)

Available Now

from your supplier. For complete information about W-K-M's new Pressure Sealing Gate Valve . . .

Write for Catalog 1200

5907

W-K-M 40 SERVING INDUSTRY YEARS

W-K-M DIVISION OF ACF INDUSTRIES, INCORPORATED, P. O. BOX 2117, HOUSTON, TEXAS

Machines also available on rental basis

"NO SHUTDOWN WHILE CUTTING INTO THE LINE with a WmSon-Hillco Tapping Machine. When the tap is completed, Williamson Stopples plug the line temporarily while the flow continues through a by-pass. You can make repairs, replace piping, connect process units and booster stations, install fittings, extend or abandon piping. It's all done without shutdown and ***WITH COMPLETE SAFETY!*** "

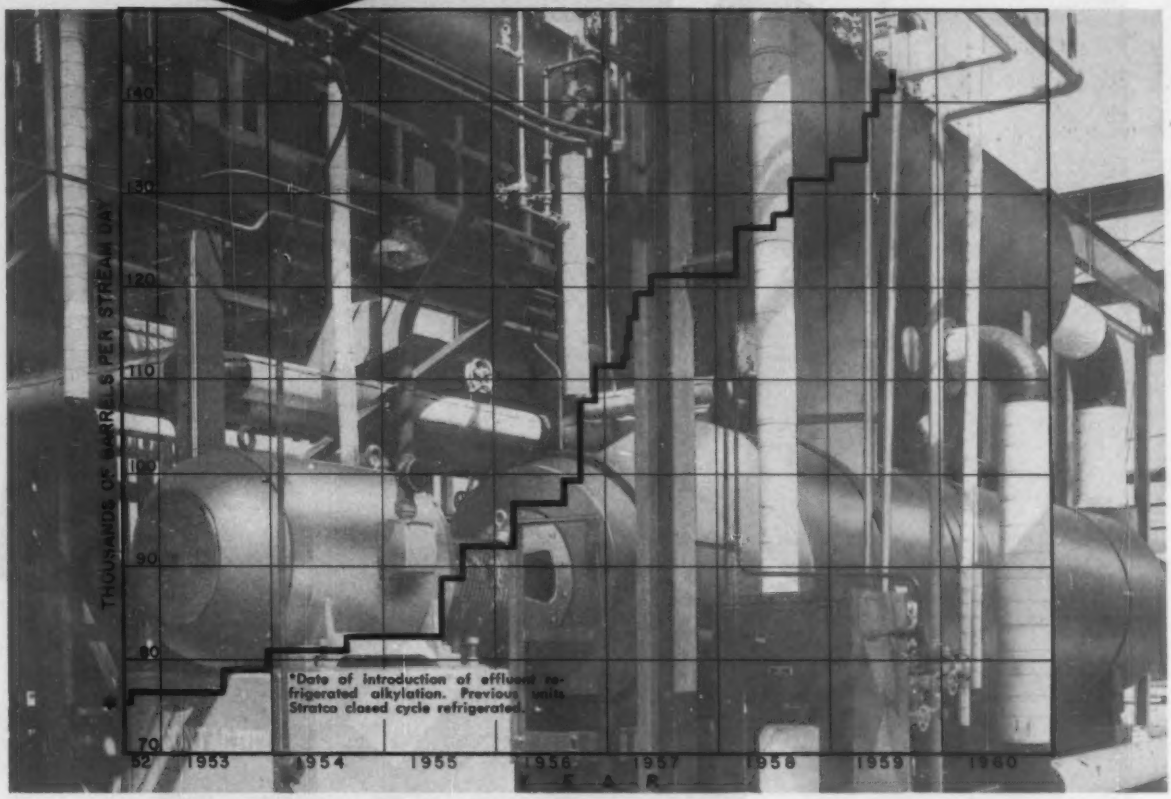
Offering years of research and experience in hot tap operations

T. D. Williamson, Inc.
P. O. BOX 40 TULSA 2, OKLAHOMA

REPRESENTATIVES AROUND THE WORLD

STRATCO

EFFLUENT REFRIGERATED ALKYLATION*



Charting An Outstanding Record of Installations

Which type of alkylation process is the most economical and efficient? According to a majority of the refiners who have installed alkylation plants in recent years, the answer is Stratco Effluent Refrigeration. The chart above traces the growth of Stratco Effluent Refrigeration since the process was introduced in late 1952. Each step on the graph indicates another plant contracted and its capacity. In this short period of time 46 units, with a total design capacity of 64,220 BPSD have been installed in 23 plants throughout the world. The trend toward effluent refrigerated alkylation is readily apparent. The Stratco process may be used to alkylate isobutane and propylene, butylene or amylene, either separately or as combined streams. Flow diagrams and electronically computed heat and material balances are available quickly and without charge from Stratco.

REPRESENTATIVES

D. D. Foster Co., Pittsburgh
D. D. Foster Co., S. Charleston, W. Va
Lester Oberholtz, Los Angeles
Rawson-Houlihan Co., Inc., Houston
The Rawson Co., Inc., Baton Rouge
F. J. McConnell Co., New York

Licensed by Stratford Engineering Corporation — We cooperate with your contractor in plant design

STRATFORD ENGINEERING Corporation

612 W. 47th St. — Petroleum Refining Engineers — Kansas City 12, Mo.

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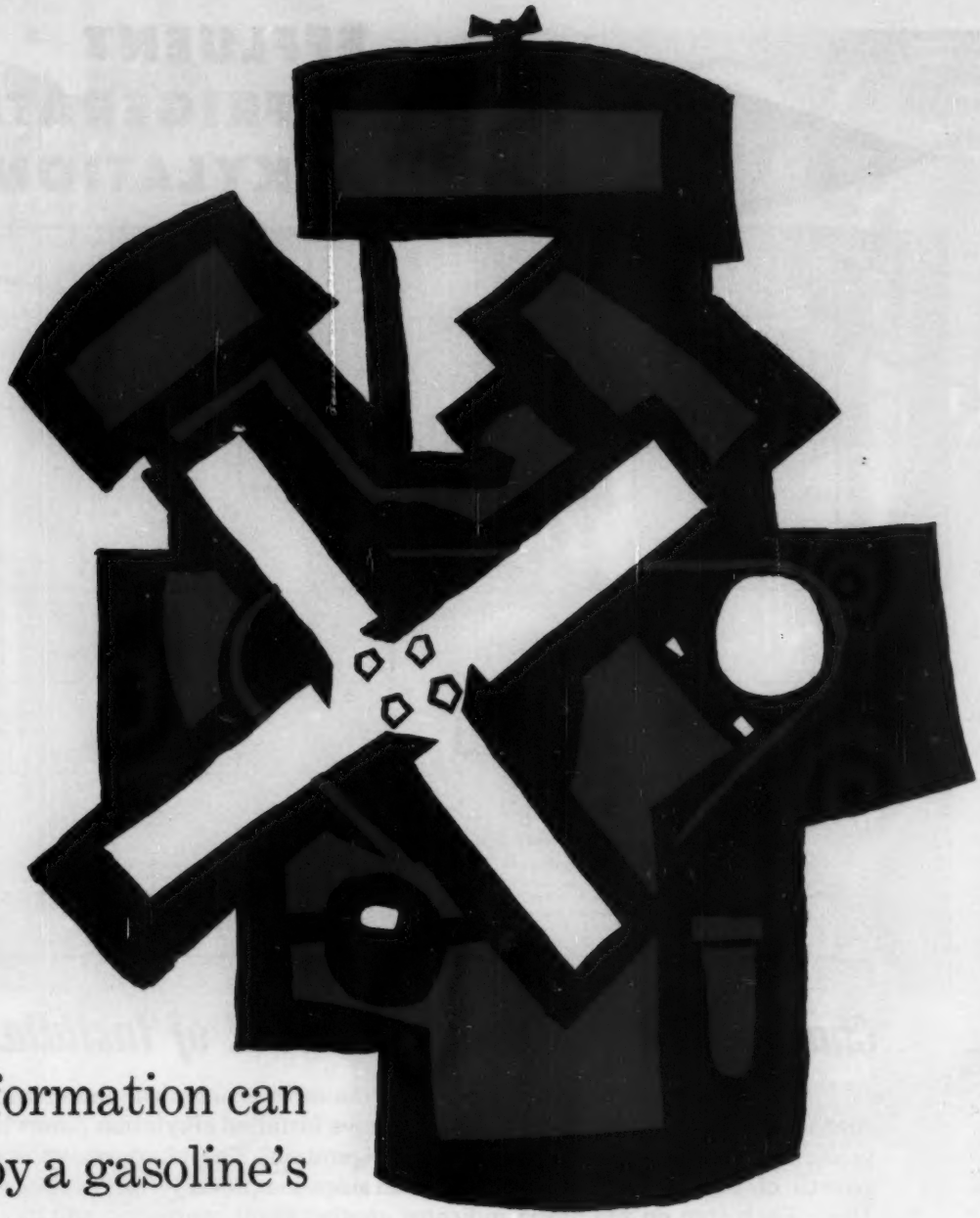


gum formation can destroy a gasoline's good name... protect yours with **Tenamene** Eastman gasoline additives

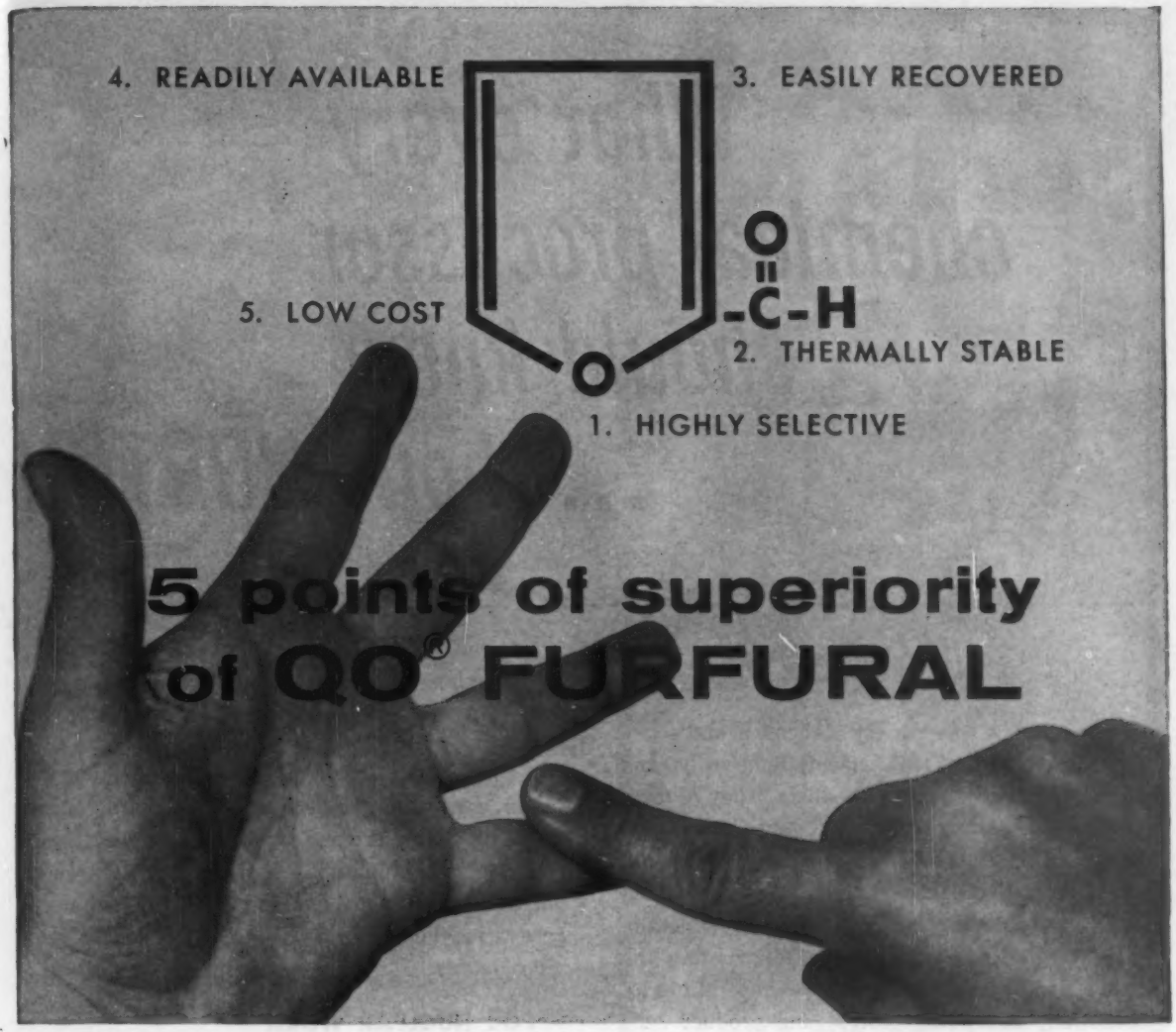
Why Tenamene? *Because* the Tenamene line offers you every principal type of gum inhibitor in commercial use today.

Because Eastman, as a basic manufacturer of the additives it supplies, maintains complete and precise control every step of the way, assuring you of a uniform product and consistent additive performance.

Because Eastman petroleum specialists are available for on-the-spot technical service to make absolutely certain you obtain the most efficient use of the additives you buy. Talk to them, for example, about the economy of bulk delivery.

You'll find Eastman petroleum specialists can give you unequaled technical service because inhibition of gum formation is their only interest. EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tenn.; Atlanta; Chicago; Cincinnati; Cleveland; Detroit; Framingham, Massachusetts; Greensboro, N. C.; Houston; New York City; St. Louis. **West Coast: Wilson Meyer Co.,** San Francisco; Denver; Los Angeles; Phoenix; Salt Lake City; Seattle.



1. HIGHLY SELECTIVE:
QO Furfural is highly selective in separating a wide variety of closely related compounds in such operations as refining of lube oil, gas oil, cycle stock, and extractive distillaton of C_4 hydrocarbons.

2. THERMALLY STABLE:
QO Furfural is thermally stable under the conditions of extraction and recovery, thus permitting long continuous plant operation.

3. EASILY RECOVERED:
QO Furfural is easily recovered. Some refiners report less than 0.02% solvent loss of the furfural circulated.

4. READILY AVAILABLE:
QO Furfural is readily available in large quantities from annually renewable raw material sources.

5. LOW COST:
QO Furfural costs only pennies per pound and has an outstanding record of price stability during its 25 year's use by the oil industry.

The Quaker Oats Company
CHEMICALS DEPARTMENT

The Quaker Oats Company — CHEMICALS — QO FURAN CHEMICALS — DEPARTMENT

340L The Merchandise Mart,
Chicago 54, Illinois

Room 540L, 120 Wall St.,
New York 5, N. Y.

Room 440L, 48 S.E. Hawthorne Blvd.
Portland 14, Oregon

In the United Kingdom:
Imperial Chemical Industries, Ltd., London, England

In Europe:
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Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France;
A/S "Ota", Copenhagen, S. Denmark

In Australia:
Swift & Company, Ltd., Sydney

In Japan:
F. Kanematsu & Company, Ltd., Tokyo

For more data on advertised products, use Readers' Service Cards, last page.

What every chemical processor should know ...about NORTON

You can meet a *wide* variety of chemical and petrochemical processing requirements efficiently and economically with NORTON Products. They're more than just outstanding refractory materials. In addition, they provide versatile combinations of chemical, physical, and electrical properties that make them valuable aids at many critical stages of production. Find out how these advanced materials from the NORTON electric furnaces can help *your* operations by substantially improving process and product . . . sharply reducing operating costs. If you wish, the NORTON Man will be happy to discuss processing problems with you at any time. Backed by years of experience in the field, he's well qualified to help. Write NORTON COMPANY, Refractories Division, 470 New Bond Street, Worcester 6, Massachusetts.

FOR CATALYSIS

A full line of catalyst carriers to meet the requirements of a wide range of feedstocks and thermal conditions. For coated or impregnated use. Size, weight, porosity, pore diameter, and purity held to close tolerances to assure precise duplication of results.

SHAPES	*MATERIALS*	*POROSITY*
Spheres	Alumina	from 10% to 50%
Rings	Silicon Carbide	
Pellets	Fused Magnesia	*Surface Area*
Granules	Zirconia	
Powders	Silica, Zircon	From less than 1
	Magnesia-Alumina	to 70 M^2/gram*
	Spinel, etc.	

Bulletin No. 7 gives full details. *BET Method

FOR FILTRATION

A wide selection of porous media for filtration, diffusion, or aeration. Made of strong, chemically stable ALUNDUM* fused alumina, they also have high resistance to alkalies and acids. Provide uniform flow, with pores uniformly distributed in needed sizes and open-pore ratios. Tubes, plates, discs. Catalog No. 140 provides details.

FOR NUCLEAR WORK

Control and shield materials, including highly stable, lightweight NORBIDE* (B_4C). Metallurgical processing refractories. Ceramic fuel pellets. Source and intermediate materials.

FOR HIGH TEMPERATURE PROCESSING

Castables: Highly versatile, easy-to-handle ALUNDUM fused alumina materials for insulation. Provide protection up to 3300°F. Shipped dry in moisture-protective bags, they can be mixed in minutes. Small, lightweight bubbles or dense grains. Bulletin 1992 offers details.

Cements: Three different heat-resisting, chemically-inert materials carefully blended to assure proper grit-size distribution. ALUNDUM fused alumina, CRYSTOLON* silicon carbide, MAGNORITE* fused magnesia. For troweling, ramming, patching, pressing or brick-laying. Catalog 863 provides more information.

products

Ceramic Spray Coatings: Hard, crystalline materials which can be applied to a wide variety of base materials to provide thermal or electrical insulation, add mechanical strength, improve resistance to wear, corrosion, and chemical activity. ROKIDE* "A" aluminum oxide; ROKIDE "ZS" zirconium silicate; ROKIDE "Z" zirconium oxide. Bulletins available.

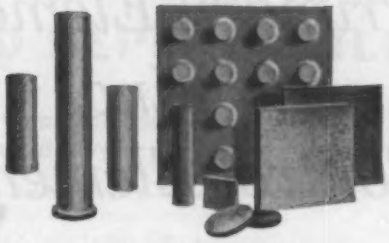
Fired Shapes: High-purity shapes of ALUNDUM fused alumina and fused stabilized zirconia offer excellent thermal insulation and chemical stability at high temperatures under both oxidizing and reducing atmospheres. CRYSTOLON silicon carbide products are available for processes involving heat transfer and abrasion resistance. Write for Catalog 862.

ALUNDUM ware has been used successfully for many years in laboratory development, experimental and analytical work involving filtering, extractions, melting, incineration, etc., because of its chemical resistance and stability in contact with reagents and solvents. Write for Catalog 793.

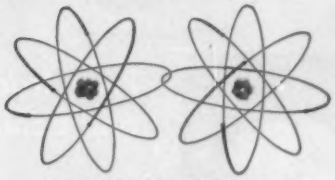
*Trade-Marks Reg. U.S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed
Making better products...
to make your products better

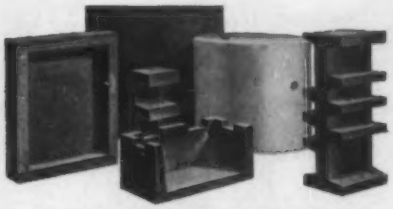
FOR CATALYSIS



FOR FILTRATION



FOR NUCLEAR WORK



FOR HIGH TEMPERATURE PROCESSING

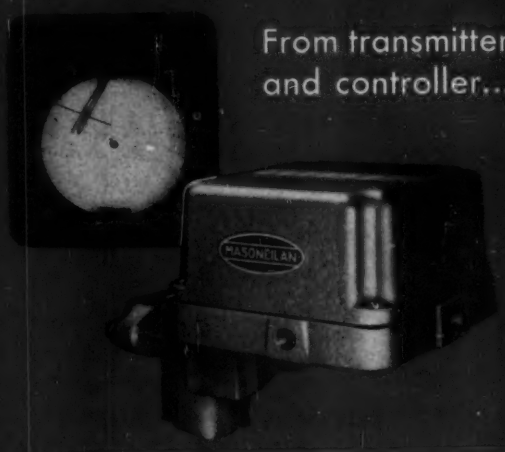
FOR THE LABORATORY

Visit with us at the
1959 EXPOSITION of the
CHEMICAL INDUSTRY
Spaces — 1289-90 & 91
New York Coliseum
Nov. 30th thru Dec. 4th

NORTON PRODUCTS: Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electro-Chemicals — BEAR-MANNING DIVISION: Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

For more data on advertised products, use Readers' Service Cards, last page.

From Primary Element to Final Control Element...



From transmitter and controller...

Through positioner and/or transducer...

To control valve

MASONEILAN
PNEUMATIC CONTROLS PROVIDE MAXIMUM SIMPLICITY AND DEPENDABILITY

Complete selection of pneumatic control devices for control of flow, pressure, temperature and liquid level.

For over seventy-five years, Mason-Neilan has developed a constantly expanding line of pneumatic controls for simplifying and advancing power and process plant, and pipeline operations.

Now, from one source, you have a selection of proven pneumatic instrument and valve designs; plus a number of electric devices which make possible further improvements in automatic control. These have been developed with the usual Mason-Neilan concern for dependability and long term efficiency.

Whatever your needs for equipment to control pressure, temperature, level or flow, call on Mason-Neilan. Examples of the major product groups in the Masoneilan line are shown here, and extensive assistance is available in selection and application.

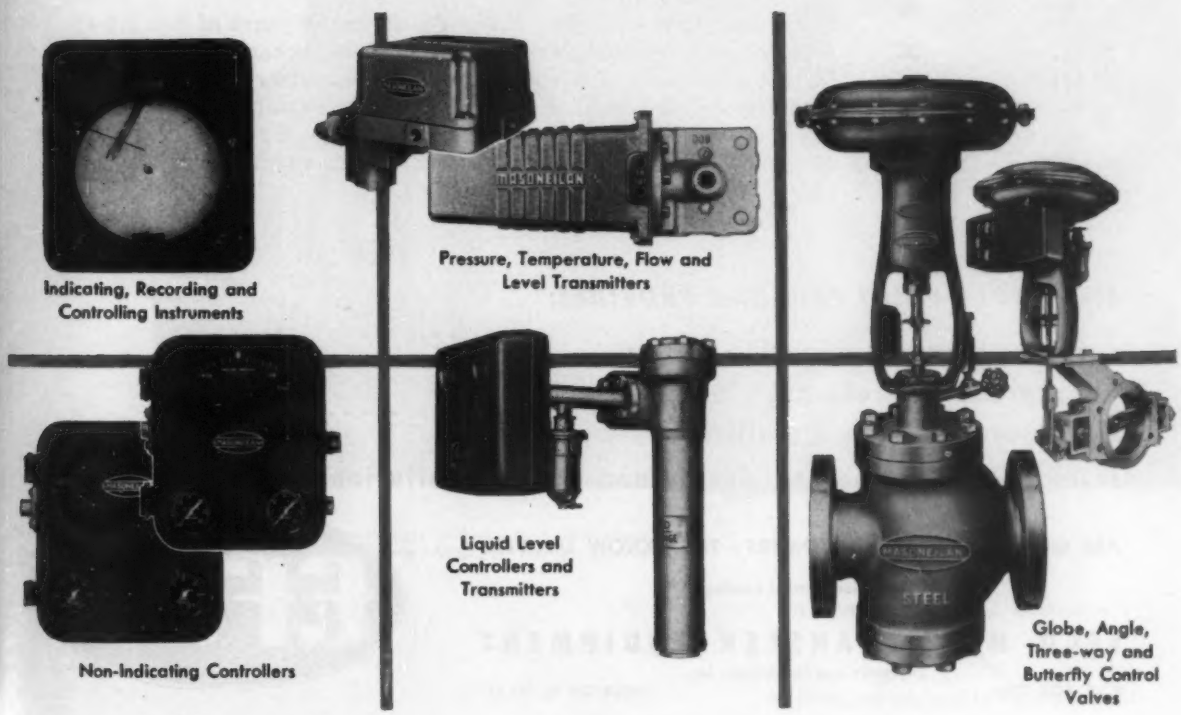
For catalog information on Mason-Neilan Controls, write to:

MASON-NEILAN

Division of Worthington Corporation

51 NAHATAN STREET, NORWOOD, MASS.

District offices or Distributors in principal cities in U.S.



Indicating, Recording and Controlling Instruments

Pressure, Temperature, Flow and Level Transmitters

Non-Indicating Controllers

Liquid Level Controllers and Transmitters

Globe, Angle, Three-way and Butterfly Control Valves

For more data on advertised products, use Readers' Service Cards, last page.

EFCO does it right

One reason that Efco does it *right* is its many years of experience in designing and fabricating heat-exchangers for the wide range of temperatures and pressures represented by ethylene plants and platinum catalyst reforming units. We are recognized specialists in handling all grades of carbon, alloy, and stainless steels, nickel, aluminum, and special low-temperature materials.

EFCO'S FOUR POINT PROGRAM PROVIDES:

service-proved engineering design
guaranteed job-ratings
complete fabricating facilities
technical service before, during and after installation

ASK OUR GULF COAST CUSTOMERS — THEY KNOW US WELL

Write for General Catalog

EFCO HEAT TRANSFER EQUIPMENT
Engineers and Fabricators, Inc.
P. O. BOX 7395 HOUSTON 8, TEXAS

EFCO

BONUS ON WHEELS An oil well servicing unit moves out to acidize a new well and bring it to peak production, or to work over an older well — a bonus on wheels. And the muriatic acid used will often be from Frontier. For responsible oil-well service firms have come to rely on Frontier muriatic acid. You can be sure of the purity of Frontier muriatic acid — low in sulphates and iron, free from fluorides and other contaminants.

Frontier muriatic acid is available in tank cars or highway tank-trailers direct from three handily located production points: Wichita, Kansas; Denver City, Texas and Dumas, Texas.

FRONTIER CHEMICAL COMPANY

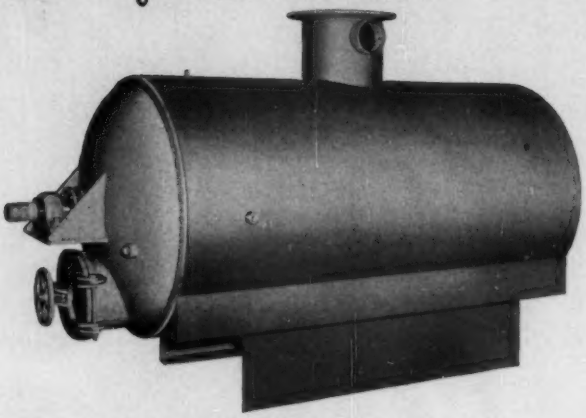
division VULCAN MATERIALS COMPANY *Wichita*

FELKER BROS. MFG. COMPANY

Metal Fabricators for OVER 50 YEARS

MARSHFIELD, WISCONSIN
Phones — 230 and 231

FELKERWELD for Endurance



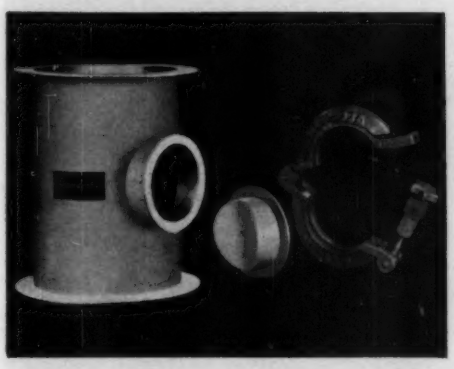
• A Pressure Cooker of open hearth mild steel fabricated to customer specifications.

Our more than 50 years' experience in fabricating plain steel, applied to stainless steel when it came into the market enabled us to develop our FELKERWELD PROCESS for ENDURANCE, with such metals as Stainless Steel, Stainless Clad Steel, Inconel, Monel, Nickel, Copper and Aluminum Bronze. FELKERWELD is your guarantee for quality workmanship.

ASME Code

Our shop is qualified for construction under the A S M E Code for unfired pressure vessels to current code requirements.

We Fabricate to Your SPECIFICATIONS



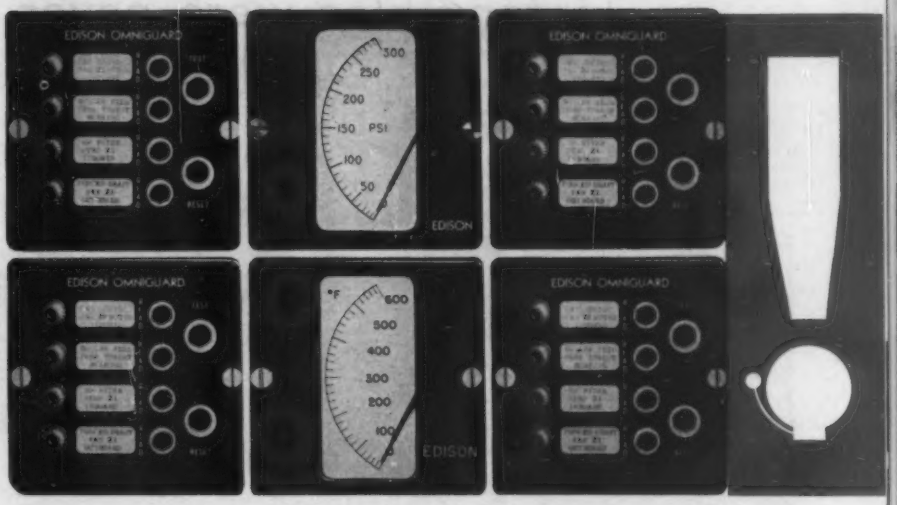
• FELKERWELD plug type CLEAN OUTS with quick opening Vee Grip Flange.

We invite inquiries on any Fabricated Products . . . write, phone or wire . . . estimates promptly furnished. Ask for our Bulletin No. 505.

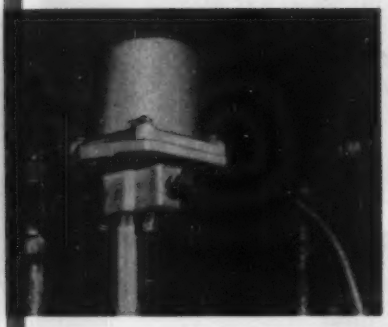
• FREEFLOW Type Stainless Steel Elbows —Fittings available in all metals.

FELKER BROTHERS MANUFACTURING CO.
PHONES 230-231 MARSHFIELD, WIS.

GUARD ALL CRITICAL PRESSURES AND TEMPERATURES WITH THOMAS A. EDISON LOW-COST, OMNIGUARD WARNING SYSTEM



Here is a versatile, highly-reliable continuous warning and monitoring system. By simply pushing a button on this panel you obtain a reading of *key pressure* and *temperature* points throughout your plant. In addition, this system provides instantaneous warning when pressure or temperature deviates from pre-set limits.

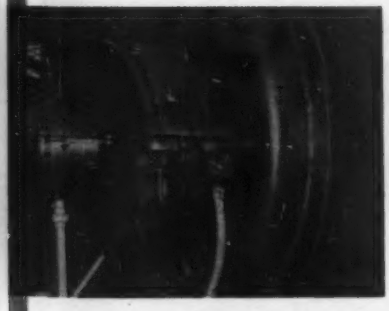


Compact, reliable Resistance Pressure Detector transmits changes in pressure to central control panel.

PRESSURE

With the Edison Omniguard system you can monitor gas, fluid or vapor pressure. Heart of the system is a rugged, accurate, pressure detector which converts pressure directly to electrical resistance—requires no millivolt conversion—no amplifier. For pressures under 60 PSI a precision capsule is the sensing element. From 60 to 3000 PSI special bourdon tube elements are used.

When pressure changes, resistance varies and this deviation is transmitted to the control panel. Units operate over ambient temperatures of 32° to 150°F. Control panels are available with a wide variety of scales and are equipped with both normally open and normally closed alarm contacts to operate any type of auxiliary device or to automatically shut down machinery or process.



Rugged, accurate Resistance Temperature Detector guards against overheating of this motor bearing.

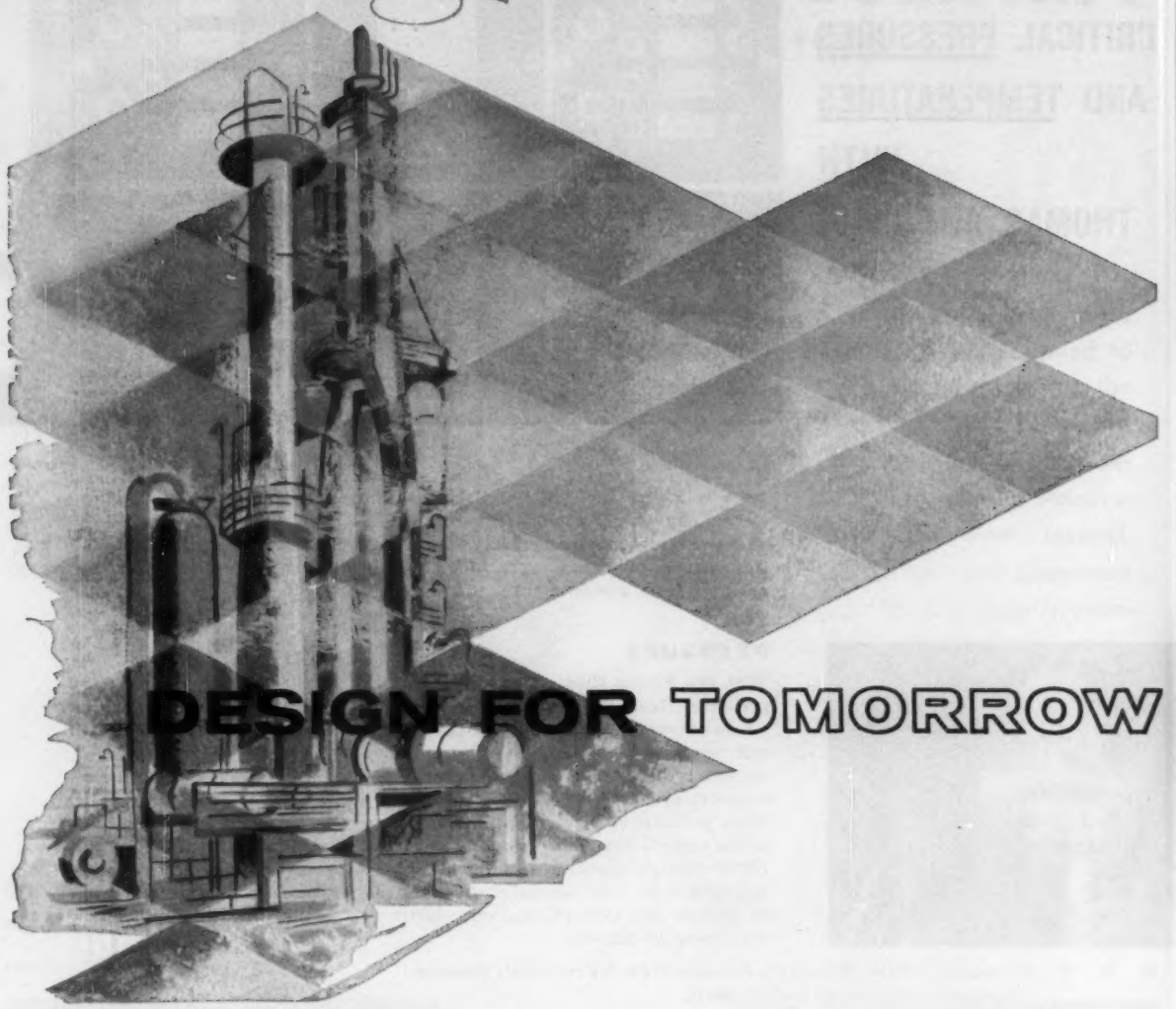
TEMPERATURE

Edison Omniguard also provides reliable protection from overheating. You can monitor the temperature of bearings, gases and liquids in critical equipments or processes. Reliable Edison Resistance Temperature Detectors have no moving parts and give instantaneous warning when limits are exceeded. Unlike other systems which only scan, Omniguard is continuously monitoring. You can obtain exact readings of temperatures in all parts of your plant from one central control panel.

For greater flexibility and reliability each detector circuit is completely independent. If one circuit is damaged, all other circuits remain "on guard." When changes or additions are required they can be accomplished quickly and easily.

Thomas A. Edison Industries
INSTRUMENT DIVISION
96 LAKESIDE AVENUE, WEST ORANGE, N. J.

intangibles were never so **important**



The time is past when a petroleum, chemical or petrochemical plant could be built to meet immediate needs. In this fast-moving field it must be designed and built with an eye to tomorrow. Flexible interpretation of plant design and broad experience in building for the future are important intangibles included in Procon service. That is why a Procon-built plant performs well today and yet can be readily adapted to the changing demands of tomorrow.

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PROCON *Incorporated*

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PROCON (CANADA) LIMITED, TORONTO 18, ONTARIO, CANADA

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WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

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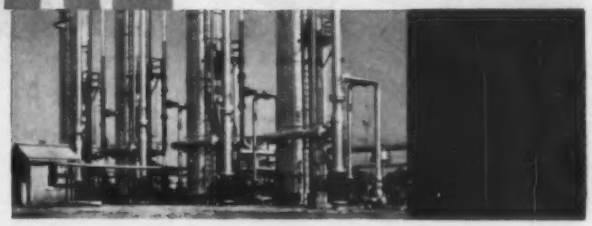
1. FABRICATION of all types of equipment (Fractionating Columns, Gas Columns, Pressure Vessels, Plate and Heavy Steel Work, Special Machines, Autoclaves, Shells, Bridge Girders) is performed to order, to specification.

2. MACHINING—Fully equipped, flexible facilities for machining to close tolerances, regardless of product size or design.

3. STAINLESS—Separate, integrated shop for stainless fabrication protects against contamination by ordinary steel.

4. DELIVERY by rail, truck or inland, coastal or overseas waterway.



FABRICATION

2 MACHINING

3 STAINLESS

4 DELIVERY

Through integrated, efficient operation, Sun Ship can reduce costs, increase your POTENTIAL. Call for an estimator or representative.

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SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.

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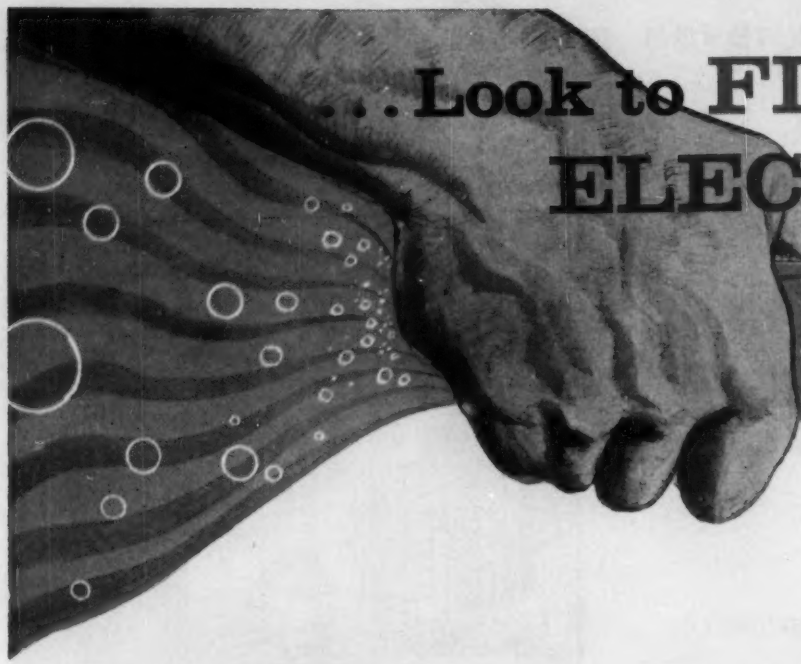
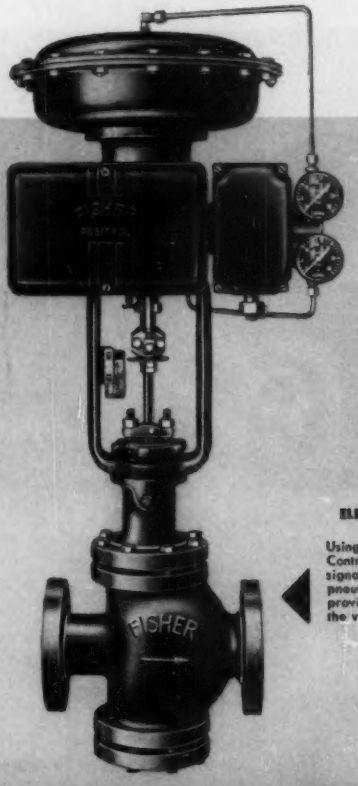
. . . Look to FISHER to ELECTRICAL





THE PNEUMATIC OPERATED PISTON "P.O.P." WITH ELECTRO-PNEUMATIC TRANSDUCER

The compactness, speed and power available from the FISHER Series 470 P.O.P. is readily made available in electrical control systems with the use of the yoke mounted Type 545 Electro-Pneumatic Transducer.

Input Current: 1 to 5 ma, 4 to 20 ma, 10 to 50 ma, d.c.

Linearity—1% of Full Range

Resolution Sensitivity—Less than 0.1% of Input Range.

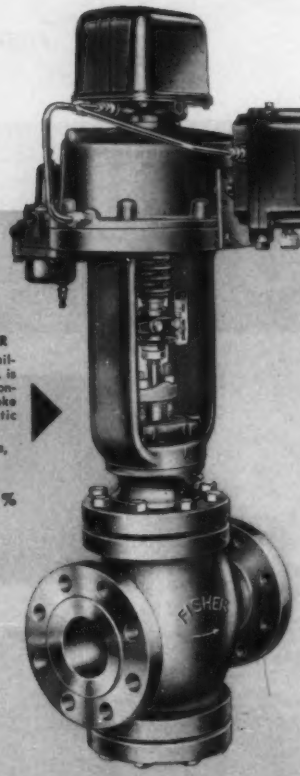
THE ELECTRO-PNEUMATIC POSITIONER "E-POSITROL"

Using a conventional Fisher diaphragm Control Valve, the E-Positrol receives a Ma signal and translates this to a proportional pneumatic signal to a positioner which provides the speed and power to operate the valve.

Input Current: 1-5 ma; 4 to 20 ma, 10 to 50 ma D.C.

Linearity—1% of full scale.

Resolution Sensitivity—0.1% of input range.

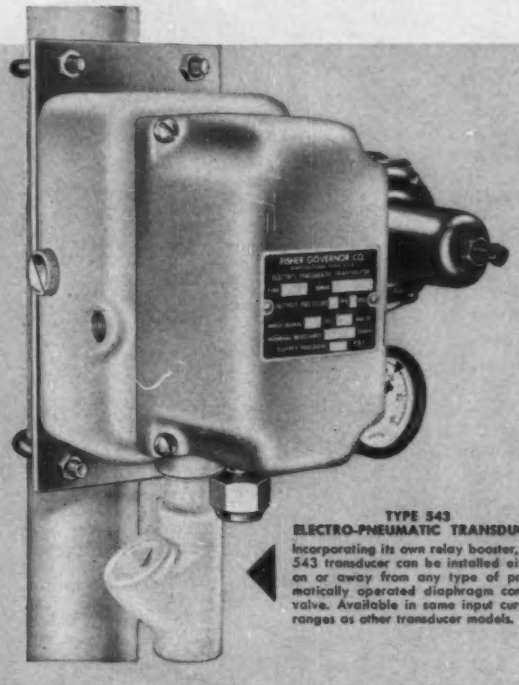


IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

supply the muscles for your CONTROL SYSTEMS

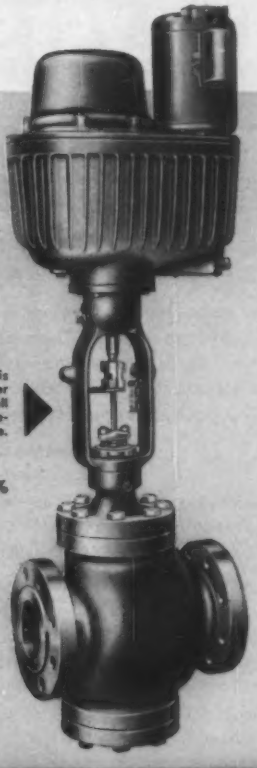
The old adage, "a chain is as strong as its weakest link" can be equally applied to the "muscle" or more correctly the final control element on any control loop. The importance of a control valve in an electronic system should never be considered lightly and that is why you should look to Fisher for assurance in furnishing dependable and accurate control valves for your electrical or electronic system.

Described below are three types of actuators that offer an exceptionally practical and economical approach for control valves in electrical control loops.



TYPE 543 ELECTRO-PNEUMATIC TRANSDUCER

Incorporating its own relay booster, the 543 transducer can be installed either on or away from any type of pneumatically operated diaphragm control valve. Available in same input current ranges as other transducer models.



THE TYPE 350 ELECTRO-HYDRAULIC ACTUATOR

In electrical control systems where air is not available or desirable, the Fisher Electro-Hydraulic Actuator provides all the necessary requirements for a dependable and accurate control valve.

Maximum Stem Thrust..2000 pounds
Stroking Speed.....0.37 in./sec.
Resolution Sensitivity...less than 0.05%

FISHER® Controls
SINCE 1880

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIPMENT CO., CORAOPOLIS, PA.

HARSHAW CATALYSTS

are available in 6 forms:

TABLETED • EXTRUDED • GRANULAR
SPHERES • FLAKES • POWDERS

We'll assist you in developing the best and most economical catalyst for your needs. Our more than 20 years catalyst experience and acres of production and research facilities are ready to work for you. Harshaw produces carloads of catalysts every week —this capacity guarantees prompt shipment of your catalyst order.

PREFORMED CATALYSTS
to fit special process requirements

Hydroforming • Cyclization • Oxidation • Dehydrogenation
Dehydration • Desulphurization • Alkylation • Hydrogenation,
Hydro treating • Chlorination

CATALYTIC CHEMICALS SUPPLIED BY HARSHAW

Aluminum Nitrate	Metallic Soaps (Cobalt, Manganese)	
Manganese Nitrate Solution	Cobalt Nitrate	Copper Nitrate
Nickel Carbonate	Nickel Formate	Nickel Nitrate
Nickel Sulfate	Sodium Methoxide	Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

Write for Free Book

HARSHAW

THE HARSHAW CHEMICAL CO.
Chicago • Cincinnati • Cleveland • Detroit
Houston • Hastings-On-Hudson, N.Y. • Los Angeles
Philadelphia • Pittsburgh

For more data on advertised products, use Readers' Service Cards, last page.

QUESTION:
What "priceless extras" will you find in Worthington high speed turbines?

for answer, turn page ——————→

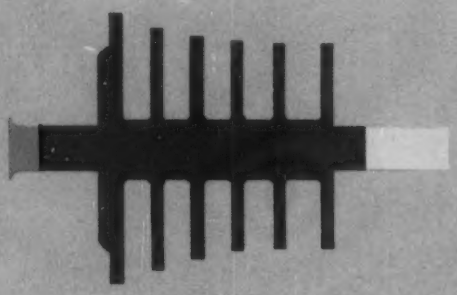
4920 hp, 7000 rpm Worthington turbine driving a centrifugal compressor at Sinclair Refining Co.'s East Chicago, Ind., plant

ANSWER:

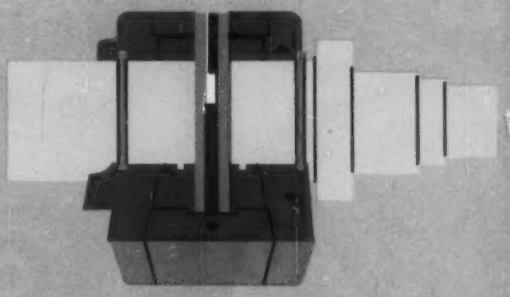
Six quality features . . . key to reliability

Reliability is the ultimate goal of every step that Worthington takes in the design and manufacture of compressor-drive turbines. Worthington reliability is confirmed by 32 years of experience in this specialized field and over 1,257,643 installed horsepower driving all major makes of compressors. When planning your next centrifugal compressor installation, *regardless of compressor manufacture*, be sure to specify a *Worthington* turbine to assure top reliability with flexible, fast and specialized customer services. Worthington Corporation, Wellsville, New York. 48-5

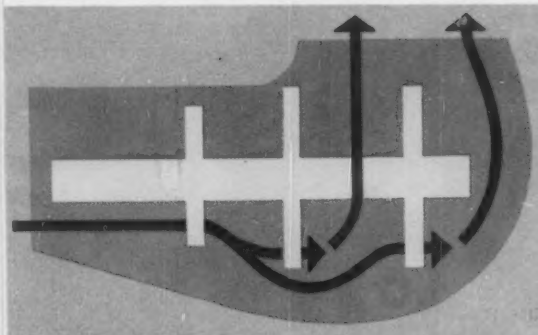
WORTHINGTON



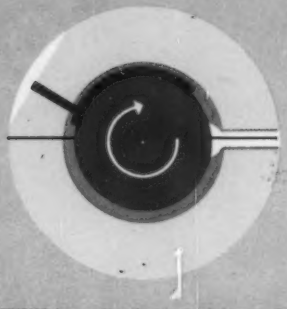
SOLID ROTORS—wheels forged integral with the shaft—provide a more rugged, conservative design.



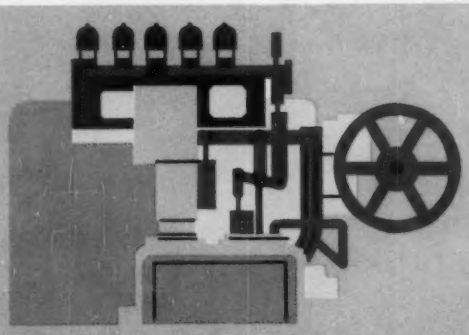
KINGSBURY-TYPE THRUST BEARINGS withstand heavy thrust loads. Shoes pivot, forming a wedge-shaped oil film between thrust collar and bearing surface.



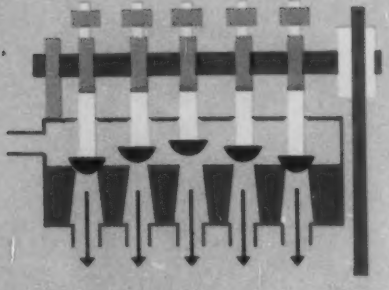
DOUBLE-FLOW EXHAUST—the last stage is divided into two wheels—reduces blade length, increasing efficiency.



ANTI-OIL-WHIP BEARINGS keep vibration to a minimum. An oil dam in upper half of bearing builds up a pressure pad, keeping rotor firmly in place.

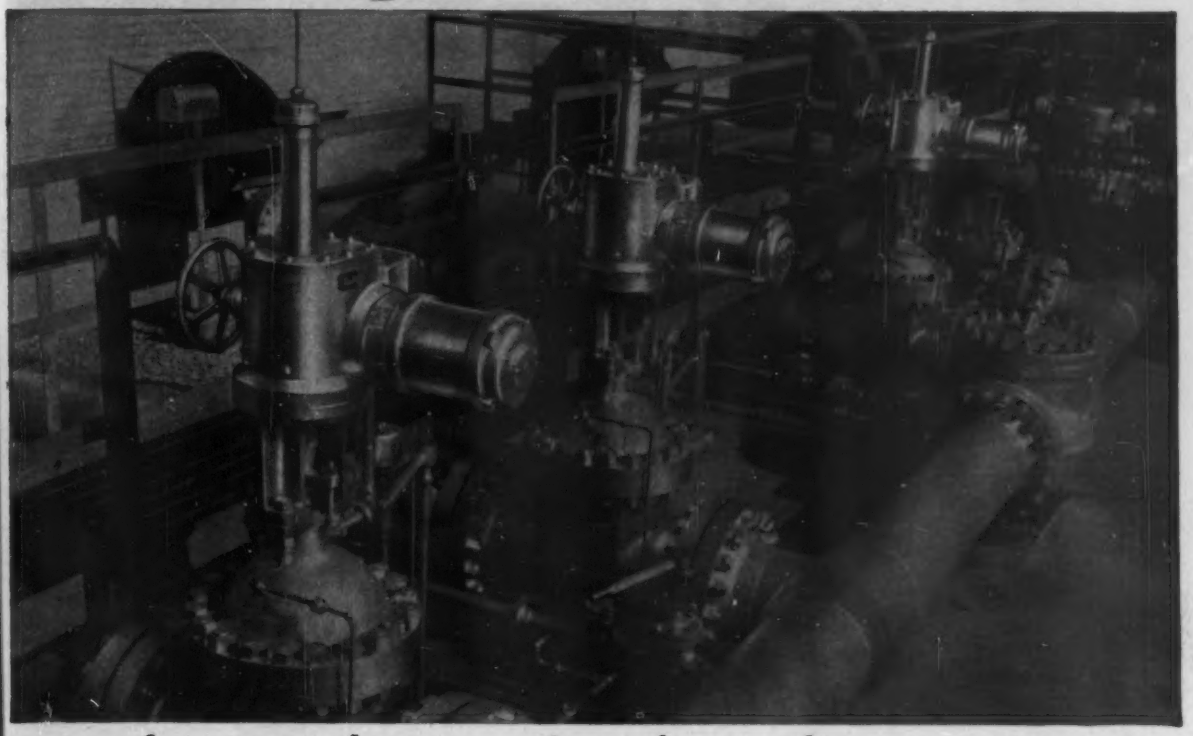


SENSITIVE SPEED GOVERNING SYSTEM provides close control over a wide speed range. (Governor takes air impulses from an outside controller to vary speeds.)



CAM-OPERATED AUTOMATIC NOZZLE CONTROL. Each valve, with separate cam, controls a group of nozzles for maximum economy at all loads.

LimiTorque VALVE OPERATORS...



. . . for mainline crude-oil pipeline service at Cushing, Okla. Pumping Station of Shell Pipeline Co.

The valves shown above are 12" Venturi type manufactured by Darling Valve & Manufacturing Co., and they are push-button opened and closed by LimiTorque Motorized Valve Controls . . . dependably, safely and speedily. High pressure gas and oil transmission lines and refineries throughout the World are using LimiTorque to automatically open and close valves from a conveniently located control point—eliminating guesswork and reducing labor costs. One man can operate any type of valve quickly and dependably in remote, inaccessible or hazardous locations; thus vital pipeline and refinery operating procedure can be handled easily by key personnel, safely and economically . . . Also, LimiTorque eliminates any possible damage to vital valve parts in closing, due to its unique torque limiting mechanism. LimiTorque may be actuated by any available power source, such as Electricity, Oil, Gas, Air or Water; and is available for Micro-wave control. LimiTorque controls can be field-mounted on existing valves—contact your valve manufacturer, or nearest sales-engineering office.

Cushing Station is the initiating station on the Ozark Pipe Line System, operated by Shell Pipe Line Corporation for itself and as contractor for the other undivided interest owner, The Texas Pipe Line Co.

Send for Catalog L-550, and please use your Business Letterhead when requesting a copy.

THERE IS NO SUBSTITUTE FOR

LimiTorque®

PHILADELPHIA GEAR CORPORATION

ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.

Offices in all Principal Cities

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID AGITATORS • FLEXIBLE COUPLINGS

Limitorque Corporation • Philadelphia

For more data on advertised products, use Readers' Service Cards, last page.

. . . in fluid catalytic cracking

DUCLONES® recover catalyst in world's leading refineries

Control of catalyst dust in reactors and regenerators of fluid catalytic cracking units is essential from the standpoints of operating efficiency, economy and air pollution control.

Type SDC Duclones and Ducon Dip-Leg Trickle Valves offer the ultimate in catalyst recovery systems. They have earned the enthusiastic approval of the world's leading refineries because of their consistently high efficiency, low pressure loss and long service life under high temperature and erosive conditions. Type SDC Duclones are available in a wide range of materials, sizes, plate thicknesses and multiple groupings. They can also be supplied lined with a refractory material.

Send today for Bulletins C-2058 and V-1458.

Photo courtesy Tidewater Oil Co.

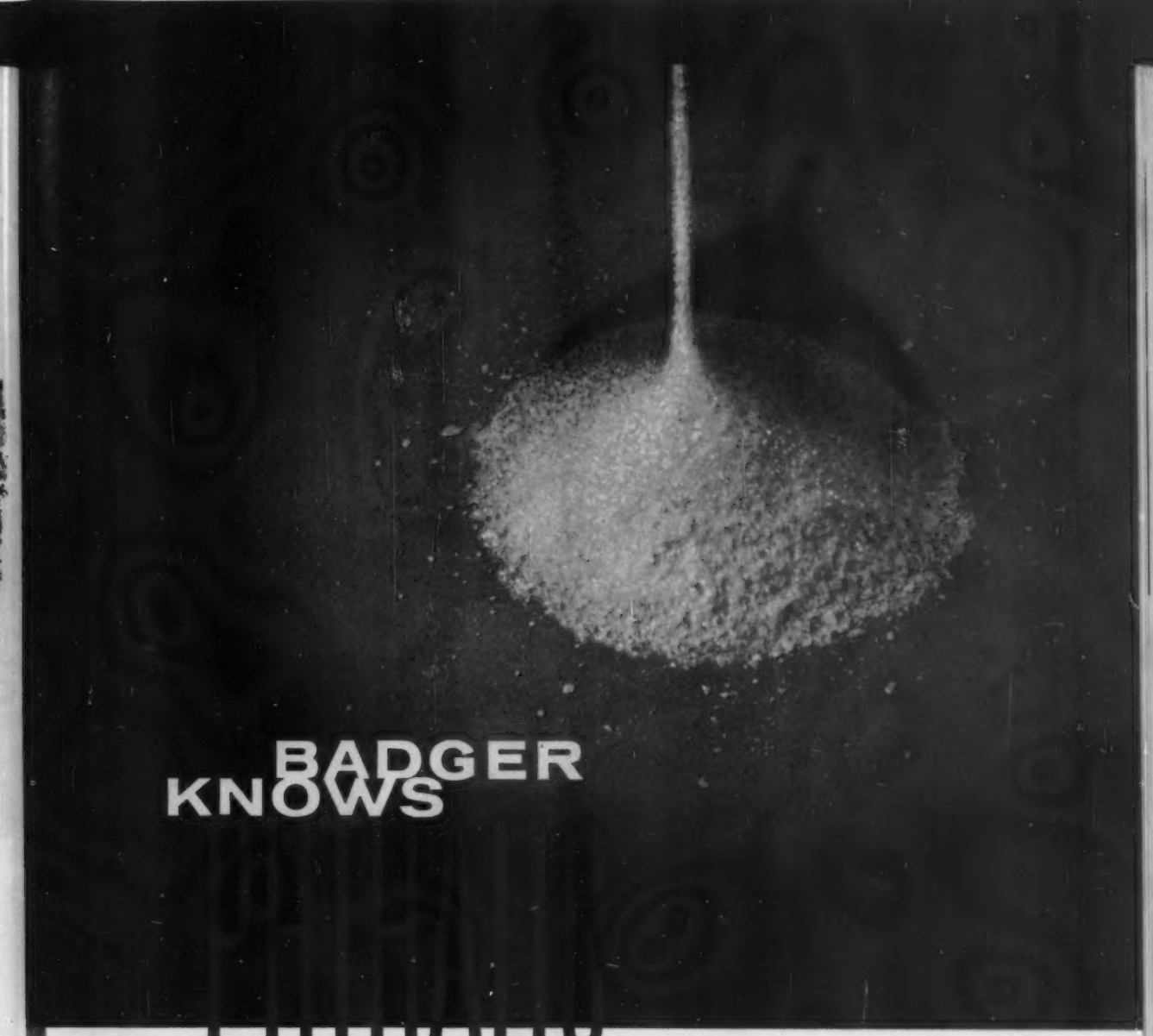
DUCON — DUST CONTROL SYSTEMS AND EQUIPMENT

the name in DUst CONtrol

THE Ducon COMPANY INC.
147 EAST SECOND STREET • MINEOLA, L.I., NEW YORK

Canadian Branch:
THE DUCON COMPANY of CANADA, Ltd.,
1131 Pettit St., BURLINGTON, ONTARIO

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES



PHTHALICS

AN EXCLUSIVE FLUID BED PROCESS... ENGINEERING, CONSTRUCTION AND OPERATING EXPERIENCE... ALL AVAILABLE FROM BADGER

Badger is now sub-licensing the fluid bed catalytic process originally developed by The Sherwin-Williams Company for its own successful phthalic anhydride plant.

Numerous refinements have been contributed to the process by Badger. These include new purification techniques, better reactor design (including more efficient heat removal), improved condensing and recovery sections for effluent gases. The process has these advantages over conventional fixed bed methods: *Low capital and operating costs* — smaller, simpler equipment saves 20% or more on plant investment, cuts utility and operating labor costs up to 30%. *Better yield* — process converts 5-10% more of feed naphthalene to phthalic anhydride. *Flexibility* — throughput may be varied over a wide range; process is easy to control. *Highest product quality* — heat color stability is high due to fewer impurities. *Safety* — fluid bed reactor virtually eliminates possibility of explosion.

With the process Badger offers unmatched engineering, construction and operating experience . . . gained in working with Sherwin-Williams . . . from the design and engineering of two current phthalic anhydride projects (see right) . . . through a broad background in fluid bed processes in general. It's as simple as this: when you are considering new phthalic anhydride facilities, come to Badger for the answers. Write or call Badger Manufacturing Company, 363 Third Street, Cambridge 42, Massachusetts.

Two major phthalic anhydride projects current at Badger

At Elizabeth, N. J., Badger is constructing a 30 million lb/yr phthalic anhydride plant for Reichhold Chemicals, Inc. When completed in late 1959, it will produce about 16% of U. S. production of phthalic anhydride made from naphthalene.

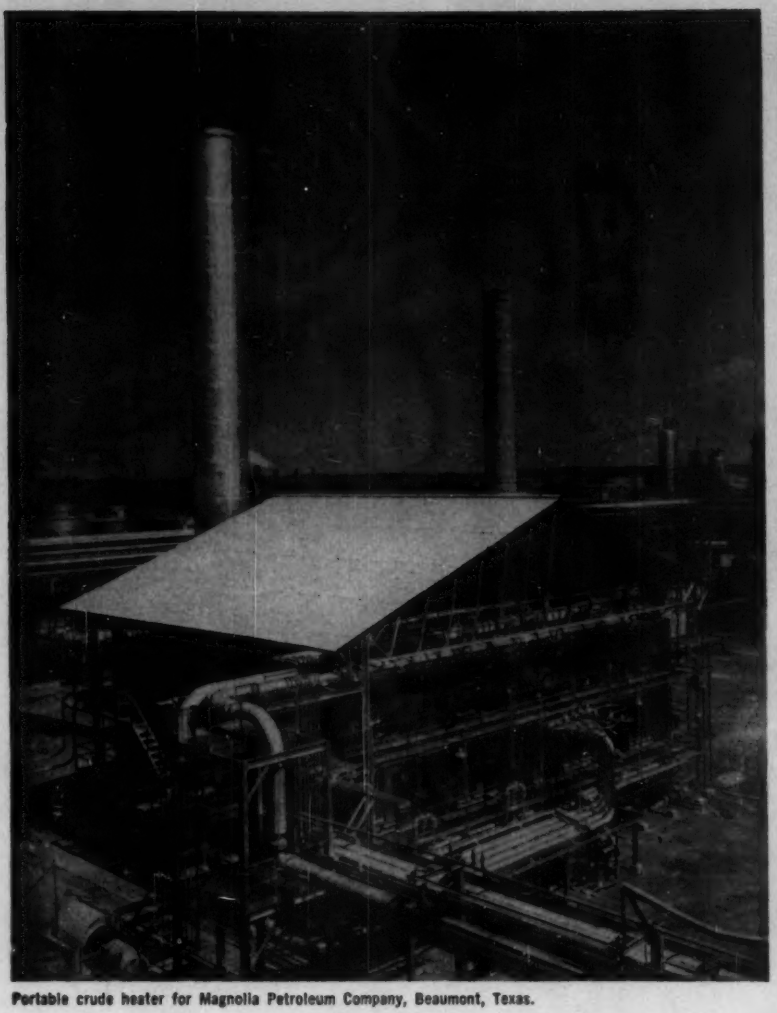
Another fluid bed plant, similar in design and capacity to RCI's, is being handled for ACNA (a subsidiary of the Montecatini group) in Milan, Italy. This plant is also scheduled to go on-stream in 1959.

built by **BADGER**

INTERNATIONAL DESIGNERS
ENGINEERS • CONSTRUCTORS

THE BADGER COMPANIES

Badger Manufacturing Company, Cambridge • New York • Houston • Canadian Badger Company Ltd., Toronto, Ontario, Canada • Badger N. V., The Hague, Holland • Badger Limited, London, England • Badger (Belgium) S.A., Brussels, Belgium • Badger (France) S. à R.L., Paris, France



Portable crude heater for Magnolia Petroleum Company, Beaumont, Texas.

Ultraformer heater for American Oil Co. at El Dorado, Arkansas.

Platformer and desulphurizer heaters for Shell Oil Co. at Deer Park, Houston, Texas.

HIGHER EFFICIENCY, LUMMUS OIL HEATERS

Lummus designs horizontal and vertical-tube oil heaters to any size, for any process—anywhere in the world

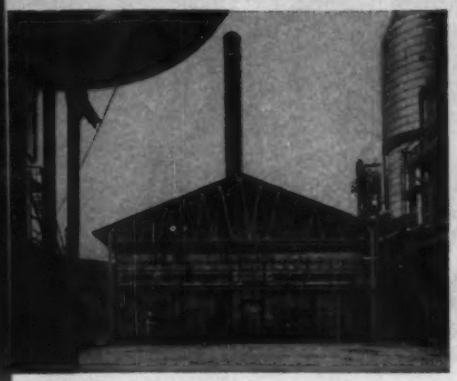
Major refiners confidently turn to Lummus on their important and difficult oil heater jobs.

In the last 25 years, the combined capacity of all Lummus oil heaters built has exceeded that of any other company in the world. The reasons: greater durability, more efficient operation, an absolute minimum of days lost to downtime.

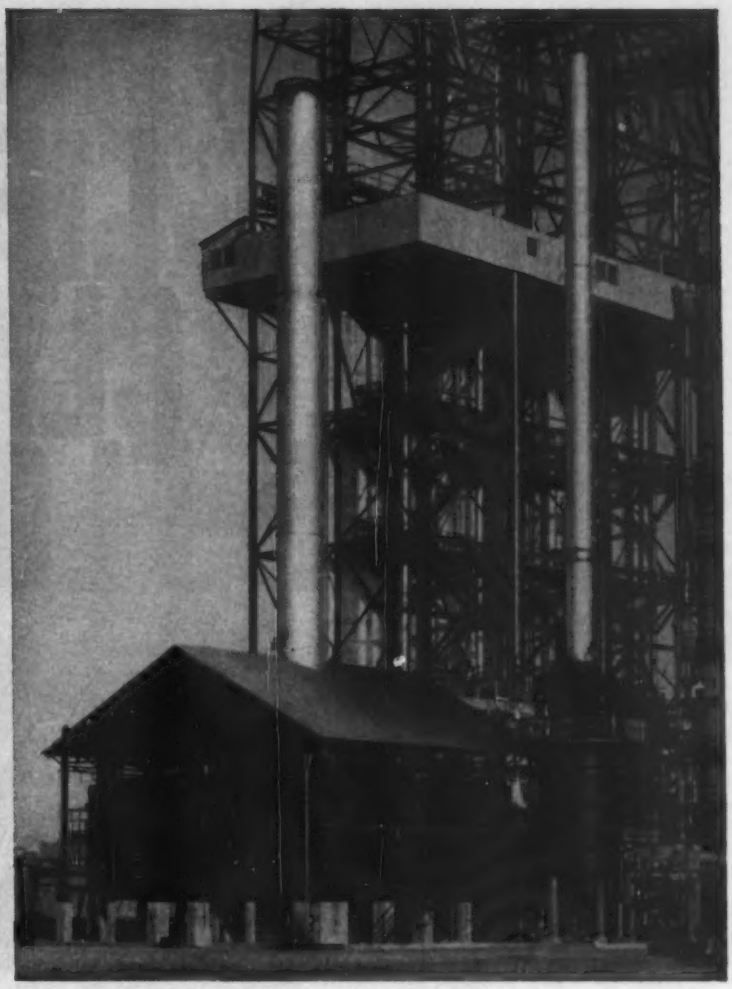
Major refiners maintain large engineering and economics staffs who can evaluate the performance of important heating equipment. They buy more Lummus oil heaters because they *know* through statistical comparison that Lummus gives them *more heater per dollar.*

Lummus offers over a quarter of a century of oil heater experience for petroleum refineries, chemical and petrochemical plants. The highly trained engineering staff of the Oil Heater Division is ready in the Lummus New York office to give each job the full benefit of its accumulated know-how in this field.

Lummus oil heaters, of both special and standard design, range from 100,000 to 300,000,000 Btu per hour. As illustrated above, neither size, type nor location of the unit presents a problem to Lummus. Because Lummus offers *every* type of oil heater, you can be sure that we will recommend the *right*



Crude heater for Socony Mobil at Paulsboro, N. J.



Delayed coker heater for the American Oil Co. at Yorktown, Virginia.

MINIMUM DOWNTIME MAKE LUMMUS PREFERRED AMONG MAJOR REFINERS

unit for your needs. Complete Lummus facilities are available world-wide through any of the five international Lummus companies. Equipment is designed in New York, procurement is made through the nearest Lummus international office, and the cost of the job is payable in the currency of the country in which the procurement is handled!

Consult with Lummus on your next oil heater – large or small.

LUMMUS

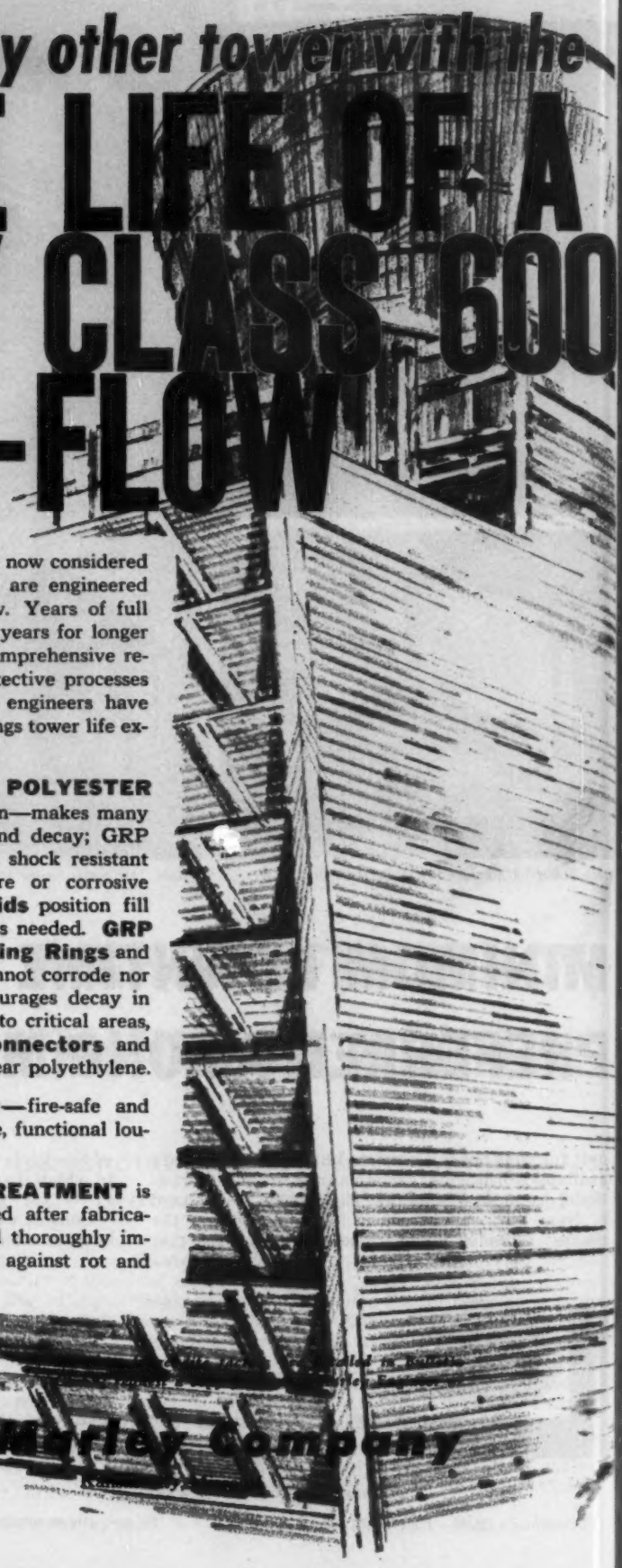
THE LUMMUS COMPANY, OIL HEATER DIVISION
365 MADISON AVENUE, NEW YORK 17, N. Y.

NEWARK • HOUSTON • WASHINGTON, D. C. • MONTREAL • LONDON • PARIS • THE HAGUE

For more data on advertised products, use Readers' Service Cards, last page.

You can't buy any other tower with the

SERVICE LIFE OF A MARLEY CLASS 600 DOUBLE-FLOW



Years . . . many more years than those now considered usual service life of cooling towers . . . are engineered into every Marley Class 600 Cross-Flow. Years of full performance; years of low maintenance; years for longer amortization. By incorporating (after comprehensive research) modern inert materials and protective processes throughout Class 600 design, Marley engineers have achieved an over-all durability that prolongs tower life expectancy beyond any current norm.

GLASS FIBER REINFORCED POLYESTER—steel-strong and impervious to corrosion—makes many components invulnerable to corrosion and decay; GRP molded **Fan Blades** are shatter-proof, shock resistant and completely unaffected by moisture or corrosive atmosphere. **GRP Fill Support Grids** position fill bars perfectly and permanently—no nails needed. **GRP Timber Connectors, GRP Retaining Rings** and **GRP Fan Cylinder Positioning** cannot corrode nor are they subject to oxidation that encourages decay in contacted lumber . . . they add vitality to critical areas, as do **Ceramic Timber Ring Connectors** and **Louver Supports** molded of rigid linear polyethylene.

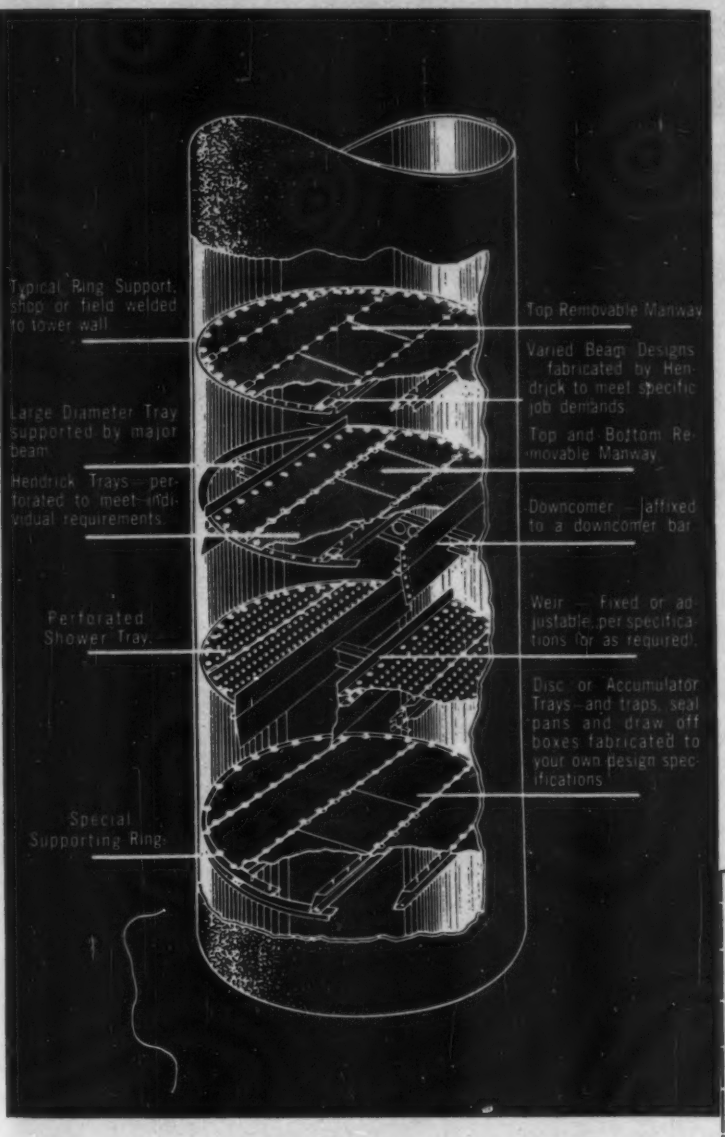
ASBESTOS CEMENT BOARD—fire-safe and wear-proof—forms casing walls and wide, functional louvers that characterize Class 600's.

MARLITH PRESERVATIVE TREATMENT is life-insurance for tower lumber. Applied after fabrication, every piece of wood is deeply and thoroughly impregnated with toxic, proven protection against rot and decay.

MARLEY®

The Marley Company

NOW! PERFORATED TRAYS... DESIGNED BY HENDRICK'S EXCLUSIVE "computer control" method


Typical Ring Support, shop or field welded to tower wall
Large Diameter Tray supported by major beam
Hendrick Trays — perforated to meet individual requirements
Perforated Shower Tray
Special Supporting Ring
Top Removable Manway
Varied Beam Designs fabricated by Hendrick to meet specific job demands
Top and Bottom Removable Manway
Downcomer — affixed to a downcomer bar
Weir — Fixed or adjustable, per specifications (or as required).
Disc or Accumulator Trays—and traps, seal pans and draw off boxes fabricated to your own design specifications

Perforated Metal · Perforated Metal Screens · Wedge Slot Screens
Hendrick Wedge Wire Screens · Architectural Grilles · Mitco Open Steel Flooring
Shur-Site Treads · Armorgrids · Hydro Dehazers · Distillation Column Internals

Hendrick perforated tray assemblies can be designed and rated with computer accuracy. Your process design figures are fed to an IBM computer on cards containing Hendrick's *exclusive* punch formulations. In no time at all the "electronic brain" digests all your specifications and submits the engineering computations best suited to your requirements.

COMPUTER-CONTROLLED trays are so efficient you can process a given flow supply in a smaller diameter column. You get a wider range of stable operation and simpler tray construction at lower initial cost. And More! Clean cut mesh reduces weeping... perfect uniformity assures long service life and less maintenance.

Hendrick perforated metal trays are available in standard metals and gauges, but for fewer production losses and less downtime, stainless steel or other corrosion-resistant metals are recommended. For more details mail in coupon, today!

Hendrick Manufactures Catalyst-Support Perforated Screen Beds.

Hendrick is licensed to manufacture Esso "Jet-Trays", Socony "Uniflux", Shell "Turbo-Grid" and Stone and Webster "Ripple Trays". Hendrick is also equipped to supply all types of trays to specifications.

HENDRICK MANUFACTURING CO.
36 Dundaff Street, Carbondale, Penna.

Gentlemen:
I would like more information on Hendrick "Computer Control" Perforated Trays.

☐ Please have representative call.
☐ Send Bulletin CI-2

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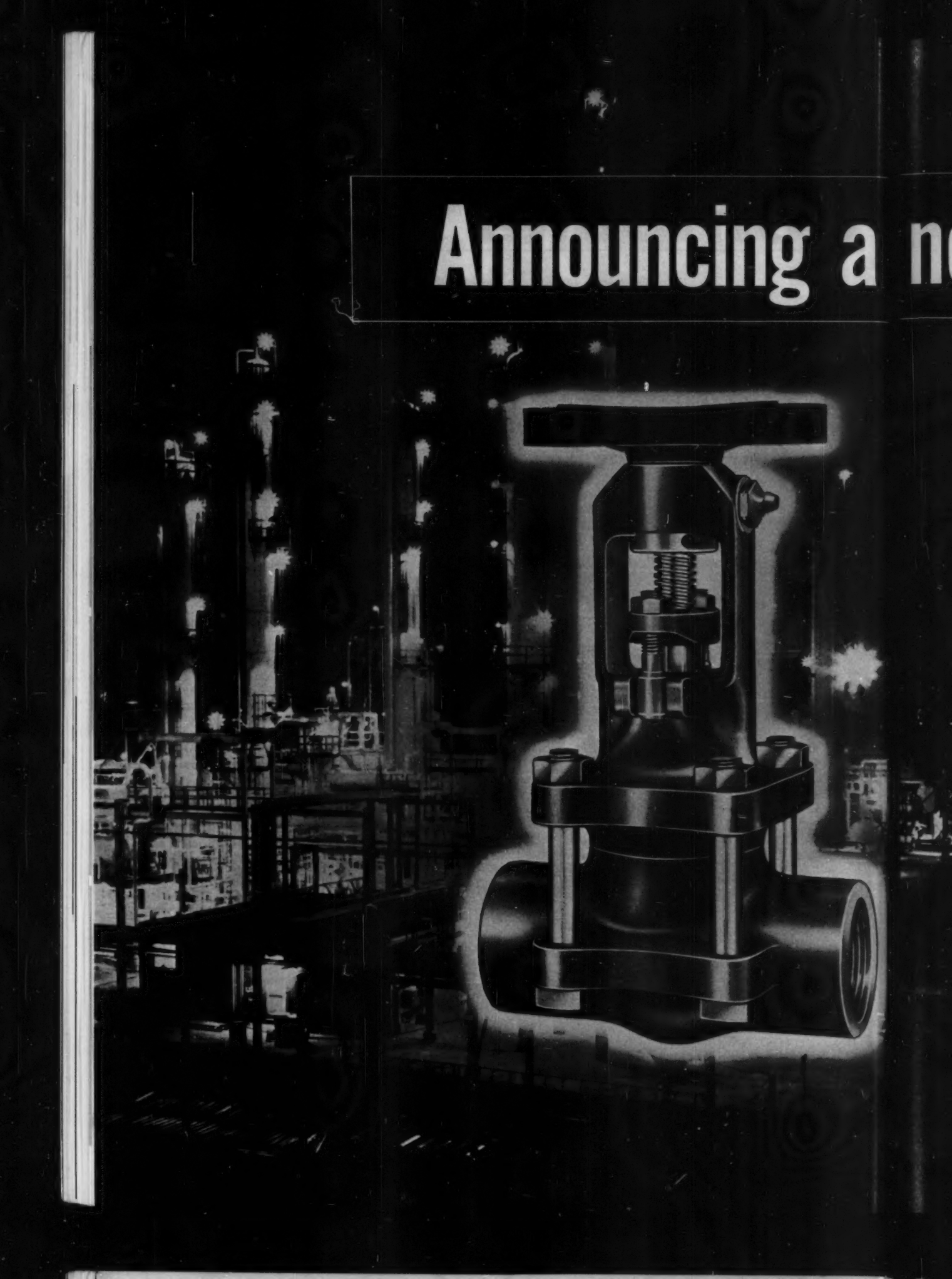
Announcing a ne



a new "Partnership"...

to serve you better, faster!

EFFECTIVE IMMEDIATELY: JONES & LAUGHLIN SUPPLY DIVISION WILL DISTRIBUTE

OIC VALVES

Here are the most advanced valve designs for today's petroleum industry.

OIC has served the petroleum industry for over a half century. Their management has always emphasized improved valve design, rigid quality control and thorough product testing.

OIC produces a complete line of bronze, iron, forged steel, cast steel and ductile iron valves. They are available for prompt delivery from any one of J&L's 75 conveniently located supply stores in the United States.

To further assure prompt delivery, store inventories are backed up by factory stocks at key points. The talents and resources of both companies are at your service to satisfy your every valve requirement.

We're out to serve you better than you've ever been served before. Just try us.

Jones & Laughlin

SUPPLY DIVISION – Tulsa

If it's sold by J&L....
It's the best available

86

With a
PACE® *Computer you can*
LAUNCH A MISSILE . . .
simulate
any dynamic problem!

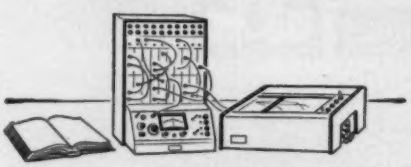
Key factors encountered by a missile in space are being simulated on this PACE Analog Computer. By turning a dial, engineers can study reaction and performance of materials under varying stresses and temperatures.

The PACE Analog Computer is helping industry, science and the military to take the guesswork out of design. With this versatile tool, engineers gain insight into the operation of complicated systems and processes. They obtain an accurate, instant-by-instant picture of performance under dynamic conditions. They can experiment with new ideas and techniques without interrupting normal production, and they can accurately predict safety factors and performance before equipment is built.

To demonstrate the value of analog computers and to aid in solving your complex engineering problems, EAI operates three Computation Centers. Here, experienced EAI analog specialists use the most advanced techniques and equipment in providing sound, workable solutions to your most difficult problems. This Computation Center service is available at a low rental rate. For additional information, write for Bulletin CC-821C.

Electronic Associates, the world's largest manufacturer of general purpose electronic analog computers, offers a complete line of analog computing equipment and accessories.
If you would like information on how actual problems were solved with PACE Analog Computers, mention your field of interest and we'll send appropriate literature.

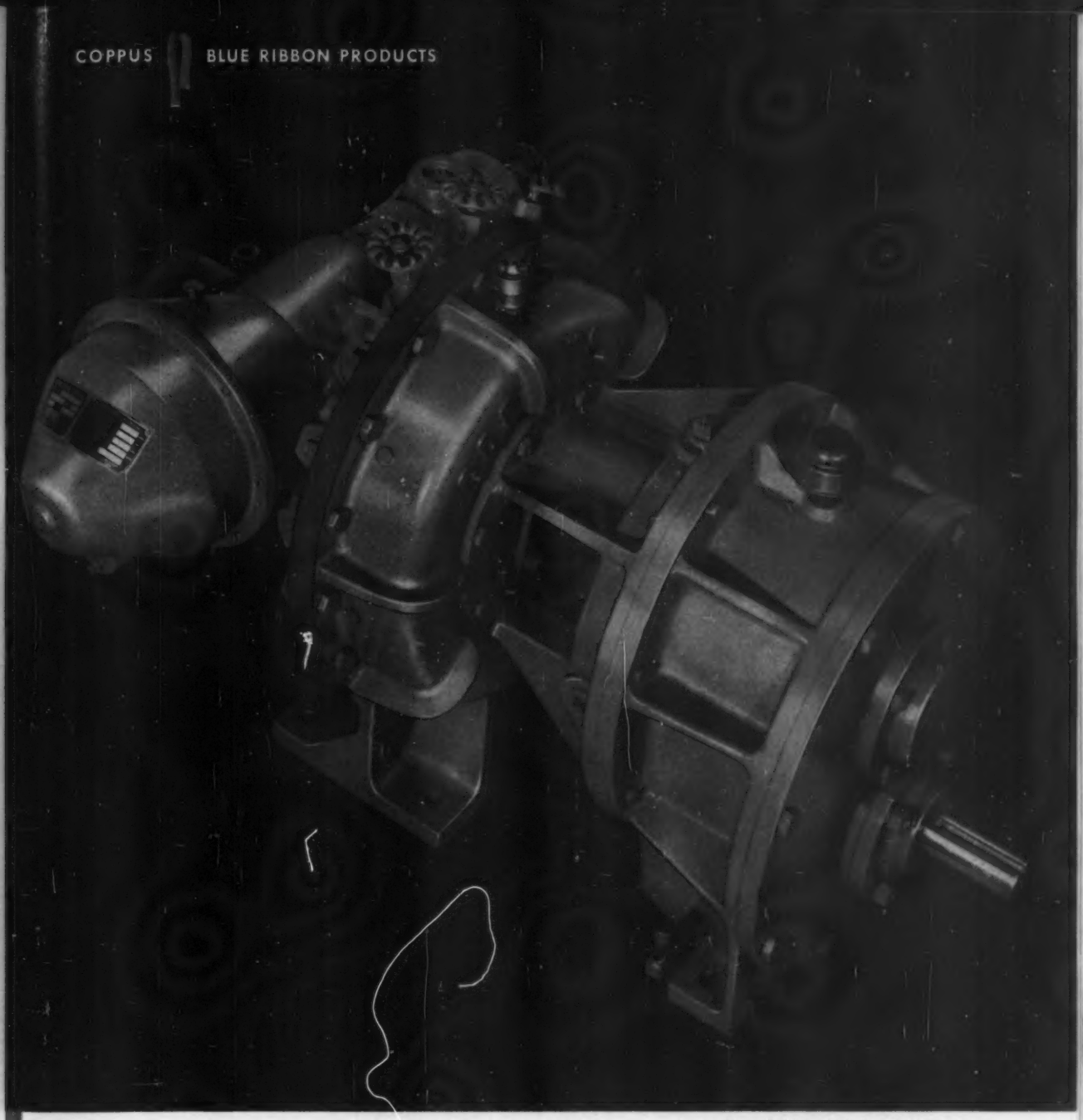
Outstanding career opportunities for engineers with proven ability—résumés invited.



New solid-state computer and desktop X-Y plotter.

EAI ELECTRONIC ASSOCIATES, INC.
Long Branch, New Jersey

COPPUS BLUE RIBBON PRODUCTS



Coppus Steam Turbine with Built-In Speed Reducer

STAMINA — You can literally *see* stamina in every dimension of a Coppus Turbine . . . rugged reliability that assures you stable, positive performance. It truly "wins" the Blue Ribbon with which it is marked . . . through advanced design, top quality materials, and thorough testing. With Coppus you're always certain of Blue Ribbon features such as these —

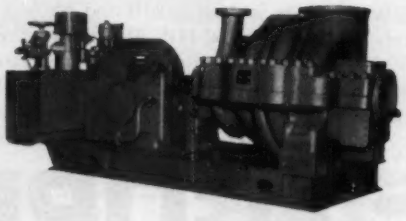
A totally enclosed governor . . . totally enclosed, independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Sizes from 1 HP to 250 HP. All Coppus Products carry the same Blue Ribbon assurance of reliable performance. For further facts on turbines, send for new Catalog 200. COPPUS ENGINEERING CORPORATION, 421 Park Ave., Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES

Background: *Compressing isobutane in refrigeration system of alkylation plant of Petro-Tex Chemical Corp.* **Foreground**: *Cutaway of high-pressure seal of Cooper-Bessemer Type RD Centrifugal Compressor.*

Matched to your needs . . . *A wide range of types and sizes of Cooper-Bessemer Centrifugal Compressors are available to assure optimum performance on your processing or air supply application.*



Undivided responsibility . . . *We can engineer the entire compressor installation, including drive and controls. Cooper-Bessemer En-Tronic® Controls* provide any degree of automation.

John Fullemann, *Chief Turboproduct Design Engineer, right, and* Kenneth Stevenson, *Turboproduct Designer, The Cooper-Bessemer Corporation, discuss...*

How reliable Cooper-Bessemer Centrifugal Compressors aid 'round-the-clock processing

For example, here's the picture at Petro-Tex Chemical Corp., Houston: The entire sulfuric acid alkylation plant banks on the dependable performance of the Cooper-Bessemer Type RD Centrifugal Compressor which handles isobutane for refrigeration. This unit operates on a continuous, 24-hour basis, handling 11,125 cfm and boosting pressure from 16.2 to 98 psia. Its constant availability is a must.

Of course, many things go into Cooper-Bessemer centrifugals to assure this kind of reliability. For example, take the two-sleeve oil film type seals shown in the illustration. This Cooper-Bessemer design is capable of sealing against pressures of more than 1000 psi, for utmost dependability in processing service.

Bear in mind, too, that the performance of Cooper-Bessemer equipment is backed by an unsurpassed service organization to help protect your plant investment and assure optimum operating economy. For further information, call our nearest office.

BRANCH OFFICES: Grove City • New York • Washington • Gloucester • Chicago
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GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE OR MOTOR DRIVEN

Refinery licks tough heat exchanger crisis with emergency tube service

A sudden tube failure at the Pure Oil Company's Refinery in Lemont, Illinois, recently put Bridgeport's condenser tube service to the test. The failure hit on Friday afternoon—just before business slowed down for the week end. Faced with the prospect of costly equipment down time, the refinery called Bridgeport's Chicago office to find out how fast new tubes could be supplied. Here's a round-the-clock story of how the emergency was licked.

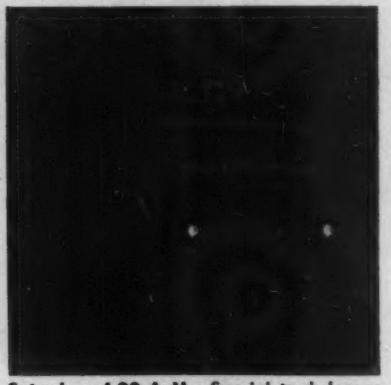
Friday, 2:30 P. M.: Salesman from Bridgeport's Chicago office learns that Pure Oil needs 900 Admiralty condenser tubes, and fast.

Friday, 3:00 P.M.: Salesman contacts our Bridgeport, Connecticut, mill and is informed that order can be delivered to Pure Oil Refinery in one week.

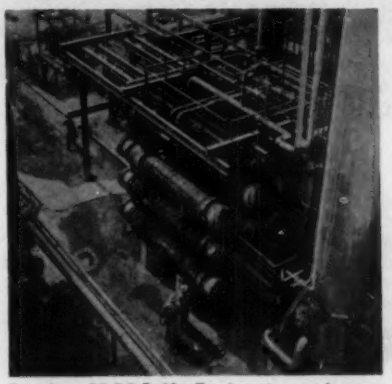
Friday, 3:30 P.M.: Sudden change in customer's needs makes immediate delivery of tubes imperative.

Friday, 4:15 P.M.: Chicago office checks through coast to coast network of Bridgeport warehouse stocks. Locates tubes at Beaumont, Texas.

Friday, 4:30 P.M.: Special night shift at Beaumont is put on job to cut tubes to special lengths and pack for shipment.



Saturday, 4:00 A.M.: Special truck leaves Beaumont, Texas, with order for Pure Oil Refinery in Lemont, Illinois.



Sunday, 11:30 P.M.: Truck arrives at Lemont Refinery with 900 Admiralty tubes, ready for repair work to start Monday morning.

While emergencies like this don't happen every day, they do prove dramatically that Bridgeport's customer service can come to the rescue. When we talk about fast service from our network of sales offices and warehouses, we mean it. Let us tell you more about our service on your condenser and heat exchanger tube needs, whether they're emergencies or normal deliveries. Call your nearest Bridgeport Sales Office, or get in touch with us direct.

Write for your free copy of Bridgeport's Condenser and Heat Exchanger Tube Handbook. (Dept. 5306)

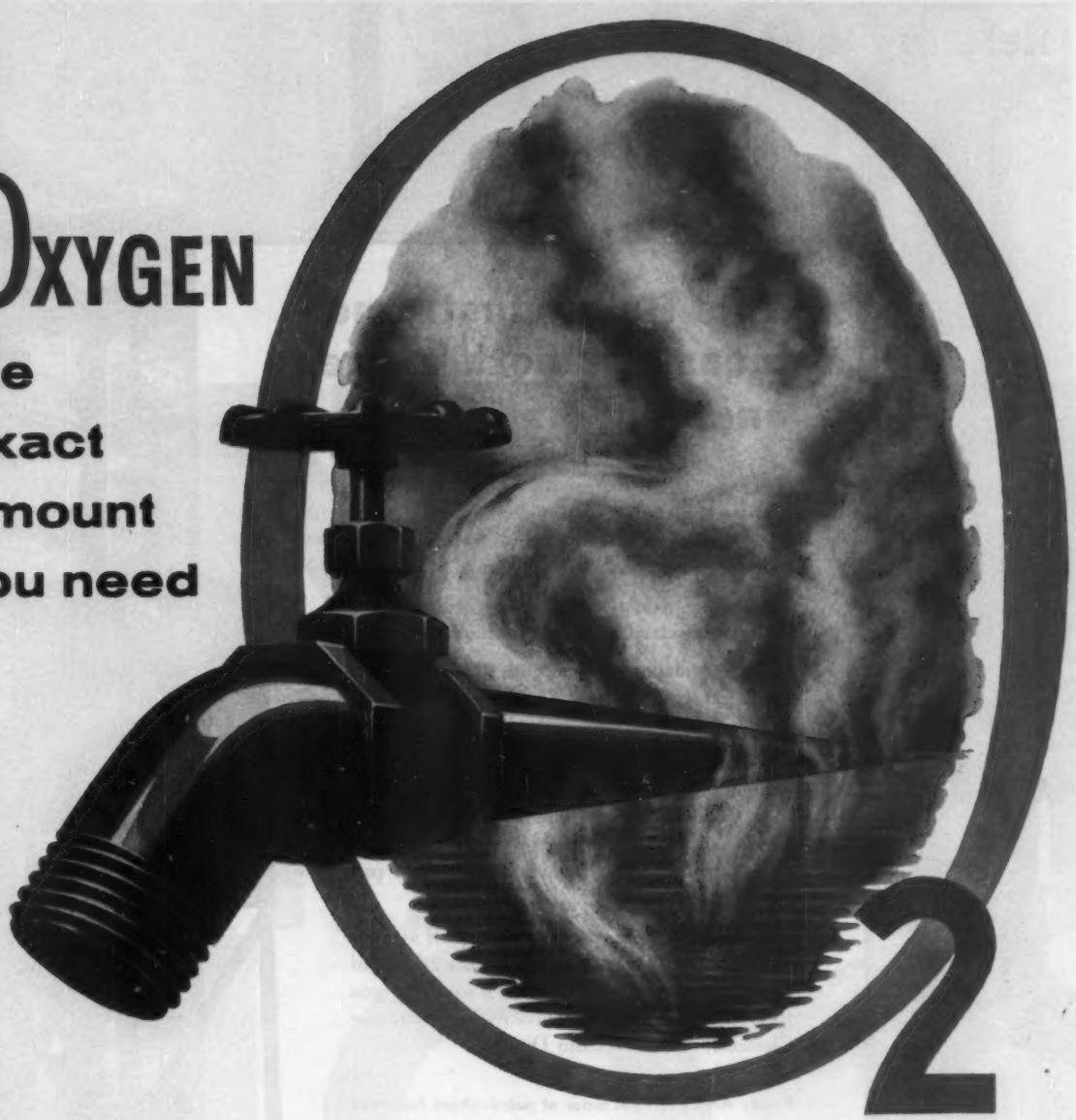
BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut • Sales Offices in Principal Cities

Specialists in Metals from Aluminum to Zirconium

OXYGEN

the exact amount you need



You get it instantly—from LINDE

You have no worries whatever about an ample, dependable supply of oxygen for your process when you buy oxygen from LINDE. Full responsibility for production, transportation, and storage at your plant is assumed by LINDE.

Tonnage oxygen. Large amounts of liquid or gaseous oxygen can be supplied from a full-scale oxygen production unit—built and maintained by LINDE—directly to your plant. You pay only for the oxygen you use, at a price guaranteed by LINDE, with no capital investment on your part.

For varying needs. A DRIOX oxygen storage unit provides a continuous flow of liquid oxygen, or converts it automatically to gas. Constant pressure is maintained, even while the unit is being replenished. Or you can get LINDE oxygen in a single flask, a cylinder, or banks of cylinders.

Take advantage of LINDE's 50 years of development and service in the industrial gas field! Write, phone, or wire Dept. PR-11, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

When you need Oxygen—call LINDE!

Linde TRADE-MARK

UNION CARBIDE

The terms "Linde," "Driox," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

For more data on advertised products, use Readers' Service Cards, last page.

This Bailey Instrument measures both oxygen and combustibles!

You can measure oxygen and combustibles with this Bailey Analyzer-Recorder . . . at less than the price of other instruments that make only single measurements.

Bailey gives you a continuous recording of *both* on the same chart for quick, simple comparison.

Speed of response is second to none . . . due to the catalytic combustion measuring unit and a high speed sampling system.

Accurate analysis and stable calibration enable the operator to keep fuel-burning equipment performing continuously in the zone of maximum combustion for greater throughput. It is possible for fuel savings, alone, to pay for the instrument.

A Bailey Engineer will be glad to call at your plant and explain how this and other advanced Bailey instruments and controls can help you to greater processing efficiencies. Or write our Chemical and Petroleum Division.

Bailey Analyzer-Recorder at petro-chem furnaces of Continental Oil Company, Westlake, La.

CP108-1

Visit our booth No. 46 at the Chemical Show

Chemical and petroleum division

BAILEY METER COMPANY

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In Canada—Bailey Meter Company Limited, Montreal

NEW!

MULTI-FUNCTIONAL VISCOSITY INDEX IMPROVERS

PARATONE

400 SERIES

ENJAY

PARATONE 400 SERIES

MULTI-FUNCTIONAL VISCOSITY INDEX IMPROVERS BOOST MOTOR OIL PERFORMANCE 4 WAYS!

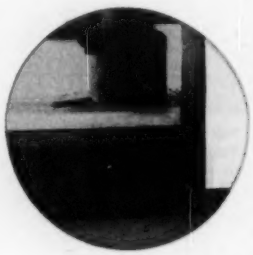
- Improves Viscosity Index
- Essentially Eliminates Sludge Deposits
- Reduces Piston Varnish
- Reduces Pour Point

The new Paratone 400 Series, latest addition to Enjay's growing list of Prescription-Balanced Paramins, is an entirely new class of multi-functional Viscosity Index Improvers.

COMBINES FUNCTIONS OF OTHER ADDITIVES

Provides the benefits of a viscosity index improver and a pour depressant as well as providing sludge dispersancy and detergency.

FIGHTS ENGINE DEPOSITS



Motor oils prescription-balanced with Enjay's Paratone 400 Series essentially eliminate sludge deposits even under the severest stop and go driving conditions. In addition, you can market an oil assuring customers of:

- Cleaner Piston Skirts
- Clean Oil Screen
- Free Flowing Oil Supply

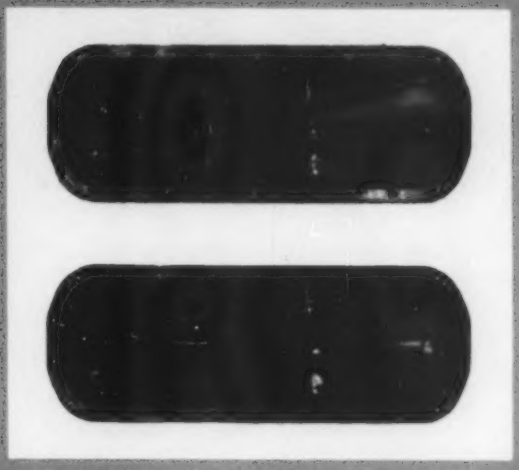
COMPLEMENTS OTHER ADDITIVES

The new Paratone 400 Series may be prescription-balanced with Enjay's or other detergent inhibitors to provide an outstanding motor oil.

THOROUGHLY TESTED

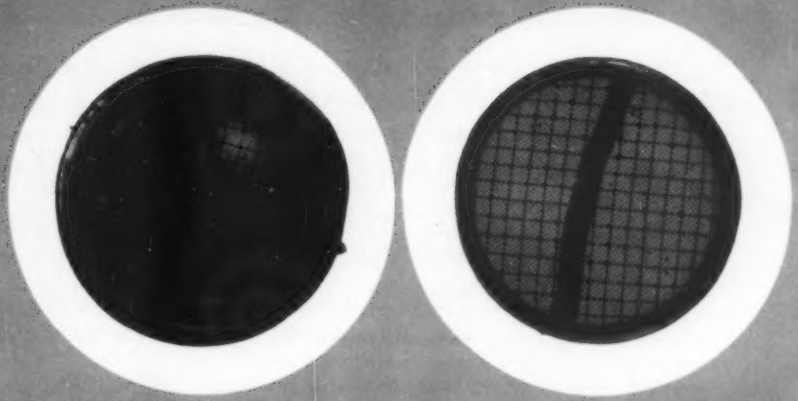
Before putting Paratone 400 Series of multi-functional viscosity index improvers on the market, Enjay subjected it to the most severe laboratory and field performance tests.

Toughest test of motor oil additive performance is the stop-and-go of *taxicab operation*. Enjoy tests additives to their utmost in a fleet of 60 New York City cabs, under every driving condition the city can offer. Each test begins with a completely new engine, continues for over 25,000 miles with oil changes only every 4,000 miles. Engines are then pulled out, dismantled, and are carefully inspected. Paratone 400 Series additives conclusively proved their worth in these tests. For details — see below and right.



Oil pan at the top shows effect of using Paratone 400 Series additive, while the other pan shows the results with conventional viscosity index improver. The oil pans tell the story. The detergent inhibitor and the base oil used were the same.

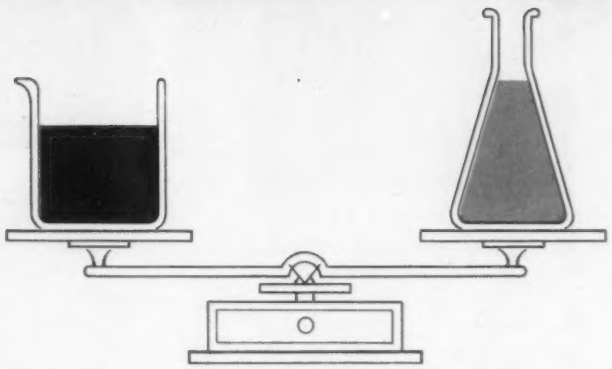
Taxi piston shows how well a Paratone 400 additive protected against ring zone deposits during the 25,000 miles.



Oil screen clogging practically eliminated! Here are two representative oil screens from the above Taxi Test. Note the dramatic difference . . . screen on the right with Paratone 400 Series additive is only 2% clogged. The clogged screen on the left resulted from an oil which contained a conventional viscosity index improver.

Up to 50% better overall sludging performance in taxi tests! You can expect this kind of result from recommended blends of Paratone 400 Series additives.

Oils formulated with the Paratone 400 Series product can easily meet the customer's specific requirements, including Ordnance qualifications.



CALL UPON ENJAY FOR PRESCRIPTION-BALANCED ADDITIVES

. . . Made to your exacting specifications . . .
Created to help you market your product SUCCESSFULLY

- Enjay serves you as a single source of the complete line of petrochemicals to improve your fuels and lubricants.
- Enjay maintains a larger technical staff devoted not only to developing new additives, but also to preparing specialized formulation to fit your specific needs.
- Quality control every step of the way from raw material to finished product is extremely important at Enjay to assure our customers of consistent high quality with each order.
- Deliveries are made from Enjay product centers throughout the country. They are expedited along the way by Enjay's new traffic control system.

The Enjay technical staff is available to help you meet your individual requirements in the additives field.

For the latest Technical Service Bulletin on the new Paratone 400 Series, or for more information on how a Prescription-Balanced Paramins Package can improve your product's performance — and effectively lower your treating costs — write or phone today

ENJAY

ENJAY COMPANY, INC., 15 West 51st St., New York 19, N. Y.
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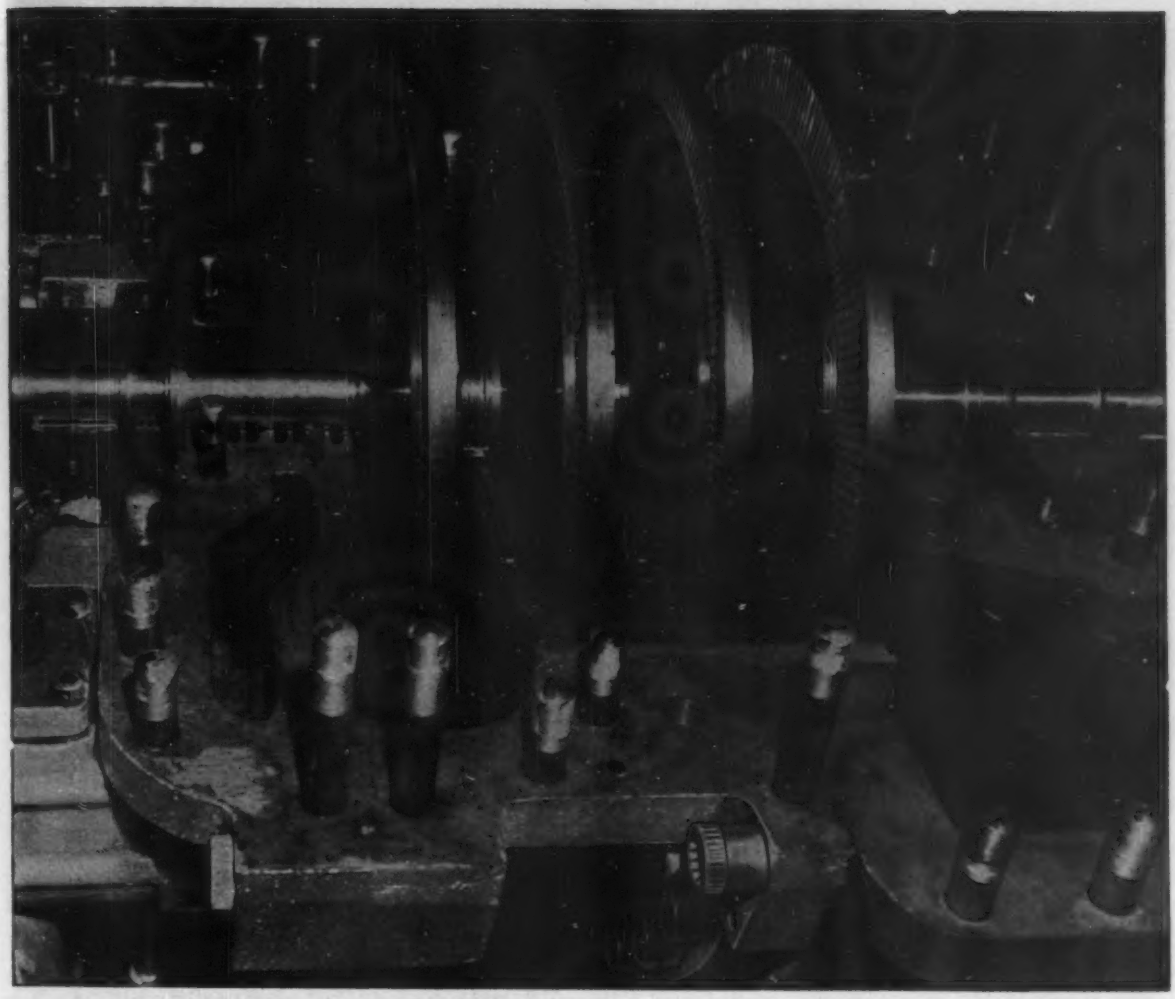
EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY



THE INSIDE STORY OF A MURRAY HIGH SPEED COMPRESSOR

DRIVE TURBINE REVEALS THE REASONS FOR MURRAY'S UNIVERSAL ACCEPTANCE

A look at MURRAY'S rugged construction from the inside shows the husky shaft and heavy accurately formed discs with generous sized hubs designed to withstand the axial and radial stresses imposed by this type of service.

Large-dimension disc rims receive the specially contoured stainless steel blades with the Murray integral shroud. This insures smooth steam passages with maximum strength.

Short bearing spans insure smooth operation and eliminate the hazard of operating in critical speeds.

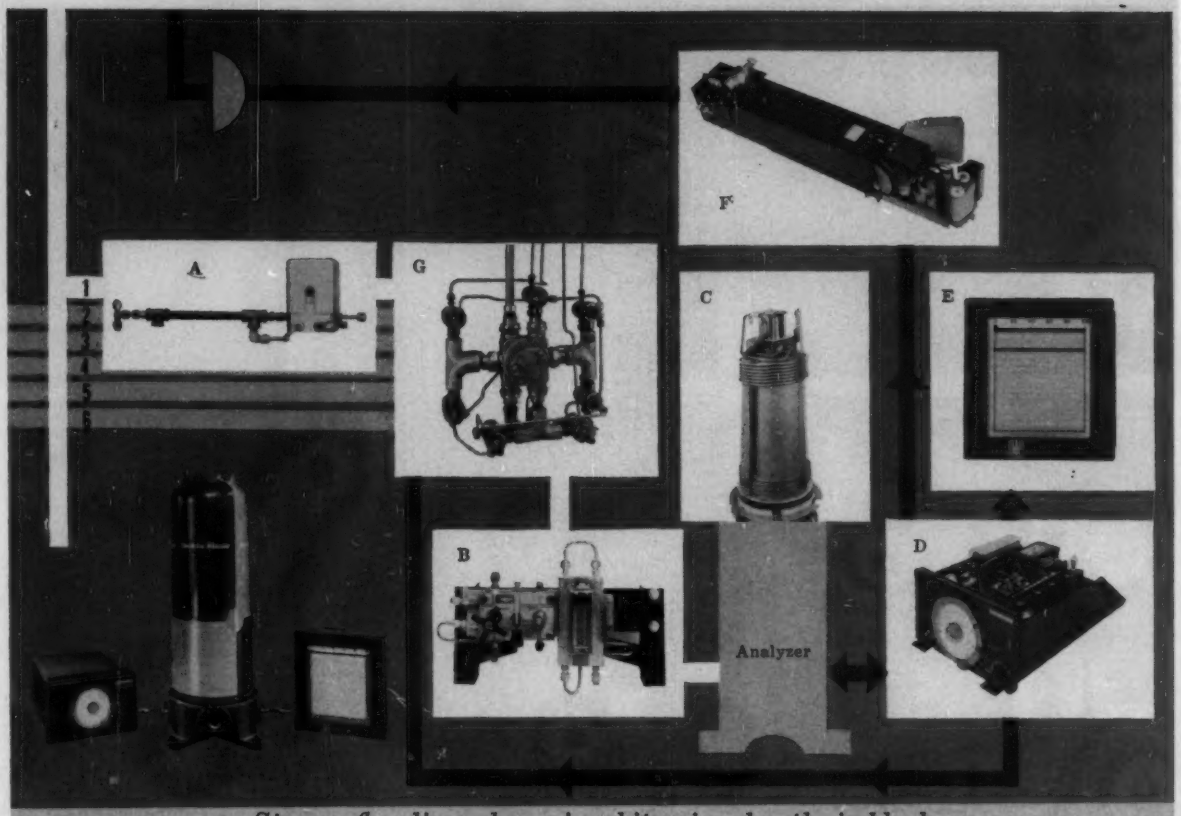
A look at the heavy flanges and husky bolting in the actual unretouched shop photo shown above bears out the extreme ruggedness that typifies every feature of Murray construction.

Our nearest representative will gladly help you solve your high speed compressor drive turbine requirements. Just write to Murray Iron Works Company, Burlington, Iowa, for his name.

Murray
TURBINES

MURRAY IRON WORKS COMPANY • BURLINGTON, IOWA
Builders of Steam Power Equipment for Nearly a Century

For more data on advertised products, use Readers' Service Cards, last page.



Stream flow lines shown in white, signal paths in black

This block diagram shows how six process streams can be selectively analyzed by the P-E Model 184-B. For brevity, Stream #1 only will be followed through the system.

Stream #1 is tapped, and the sample vaporized in the Liquid Sample Vaporizer (A). Sample #1 then flows (with the other five vaporized samples) into the enclosed, heated Multi-Stream Solenoid Switching Manifold (G). The solenoids are electrically directed by the Programmer (D). As it is selected, Sample #1 is valved into the Final Sampling Assembly (B), where it is filtered and metered into the Analyzer. The Analyzer quantitatively and qualitatively separates the sample's components by gas chromatography, produces signals which appear as a bar graph on Recorder (E).

The signal can also be fed into a Pneumatic Control Accessory (F) which produces a 15 psi signal for automatic control of one variable component of the stream.

The Analyzer with Reverse Flow Valve (C) allows for the analysis of light components individually plus a "total heavies" measurement; it back-flushes and analyzes heavy ends as a single peak, shortening analysis time in the process. The Programmer (D) is available in a variety of modes for multi-component and multi-stream analysis. It controls the Switching Manifold (G) and the Analyzer, and the readout of the Recorder (E).

All flow lines and sampling building blocks are kept above the dew point, where necessary, by steam tracing.

UNTIL NOW—PROCESS CONTROL INSTRUMENTATION LIKE THIS HAD TO BE CUSTOM-BUILT

Standard building blocks give the new P-E Model 184-B Process Vapor Fractometer the flexibility of the most advanced special engineering developments in process gas chromatography.

A new, highly versatile instrument, the Model 184-B brings automatic process control by gas chromatography within the reach of virtually any petroleum or chemical processing plant.

The Model 184-B uses *building block* sampling and sensing units in various combinations to produce process analytical systems which mean continuing extra dividends through reduced maintenance, low-cost training and highest reliability.

These standard building blocks include multi-port sampling valves for backflushing and analyzing heavy ends . . . versatile multi-column systems . . . multi-stream programmer kits . . . pneumatic units for automatic control . . . and a wide variety of sampling devices.

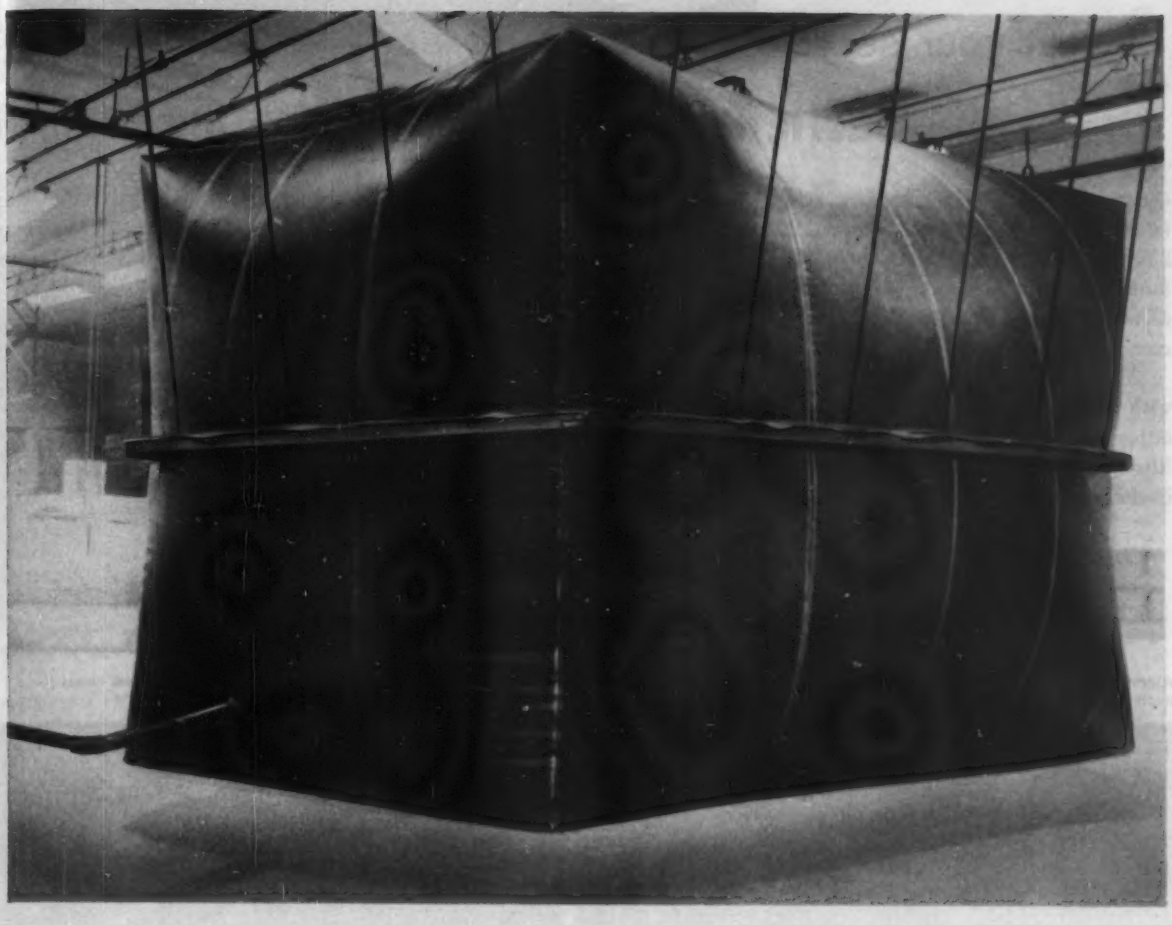
Perkin-Elmer, the world's largest manufacturer of gas chromatographic instruments, will help you in your process instrumentation requirements. For more information, write for a new descriptive booklet.

All building blocks in any P-E system conform to standard refinery and chemical plant safety practices.

INSTRUMENT DIVISION

Perkin-Elmer *Corporation*

NORWALK, CONNECTICUT



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For more data on advertised products, use Readers' Service Cards, last page.

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The plant is a two-aisle building, 177′ wide and 750′ long, with extended crane runways of 270′ and 200′ lengths at either end. Equipment includes seven cranes capable of lifting, in combined use, over 100 tons; large car bottom-heating and stress-relieving furnaces; heavy plate-bending rolls; a variety of presses and press brakes; the latest welding and X-raying equipment, plate shears, edge planers, boring mills and drills. An inquiry to the nearest contracting office will bring detailed information.

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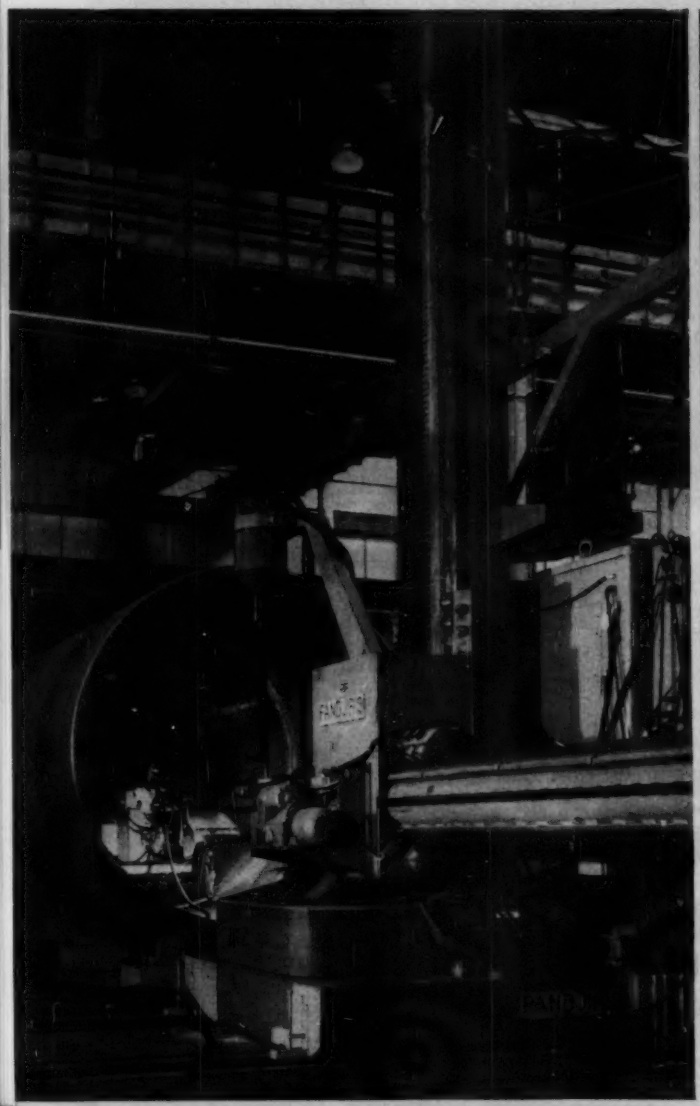
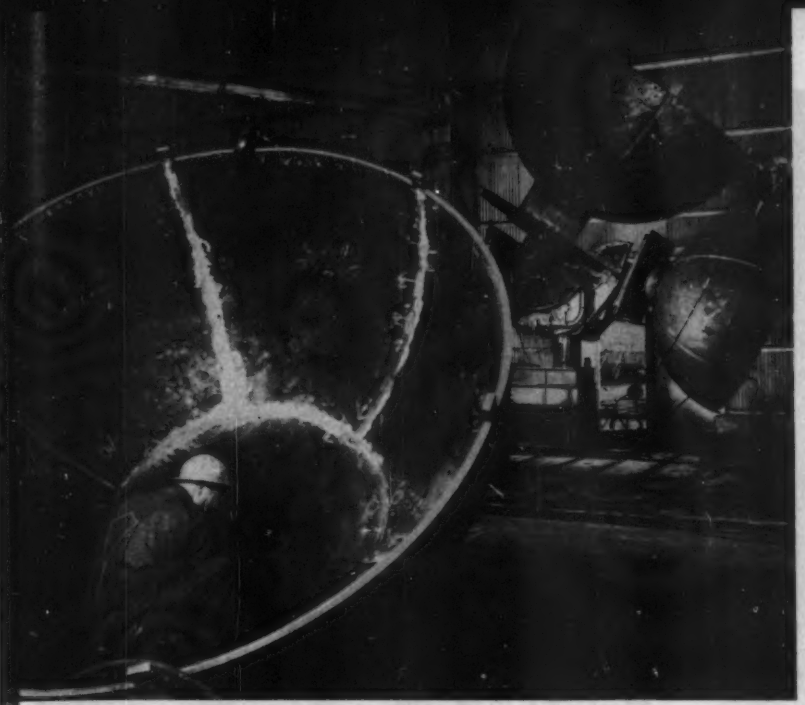
Automatic welding inside circumferential butt joint of two 1⅛" plates with boom welder.



Pressing 1¹⁵⁄₁₆" plates on 2000-ton press for hemispherical heads.

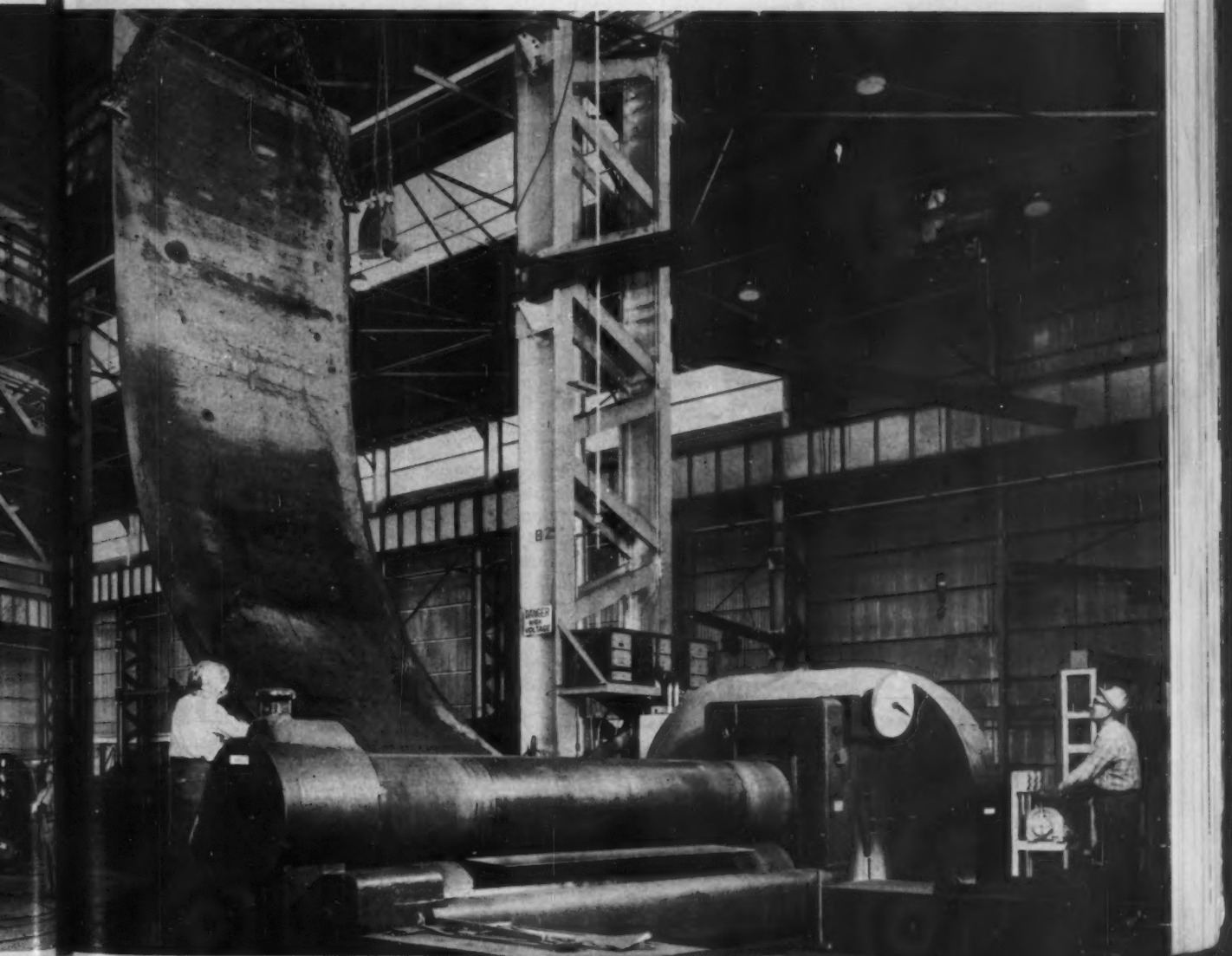


Inside of 9'-6" dia. x 1 1/16" thick hemispherical head being ground smooth.

Complete Construction Service

Possessing the most complete range of construction equipment in the industry and skilled personnel backed by over fifty years of experience, American Bridge is prepared to erect any product it fabricates.

Rolling 96" wide x 5/16" thick plate for knock-down storage tank.



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Pneumatic Transmission. Bristol Pneumatic Metagraphic receivers operate on a universal 3-15 psi signal. They indicate or record *pressure, differential pressure, absolute pressure, liquid level, flow, temperature, mechanical motion and many other variables.* Indicators and recorders interchange on a full plug-in basis. There are 36 receivers, 38 controllers, and widest variety of transmitters in the industry to choose from.

Process Computer Control Instrumentation. Now available: two entirely new Metagraphic control stations, for use with process control computer systems.

Dynamaster® Electronic Potentiometers and Bridges, using same time-proven principles as full-size instruments, can provide measurements from such electrical sensing elements as thermocouples, strain gauges, pH electrodes, photoelectric cells, etc. Same high accuracy and reliability as full-size Dynamaster instruments.

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Telemetering. Metameter® telemeter receivers, in 5" x 5⅛" case, can receive the same measurements from remote locations as their full-size counterparts. Can be installed miles from transmitter center.

Standard Pressure Gauges . . . now also offered in miniature-case, plug-in and non-plug-in types. Ranges from 0-3 through 0-100 psi.

For complete data, write The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. e.50

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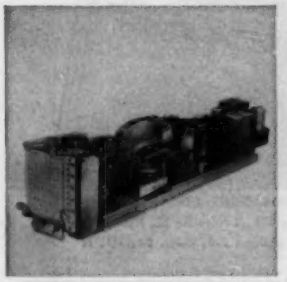
BRISTOL measurement and control



Series 663 Electronic Dynamaster potentiometer. Motor can drive almost any auxiliary devices — retransmitting slidewires, alarm contacts, analog-to-digital encoders. Available for electronic measurement—pneumatic transmission.

Metagraphic Pneumatic Controllers can plug in on receiver case, as shown here, or directly at controlled process. Proved force-balance operating principle requires almost no moving parts, nothing to wear out. 38 different models.

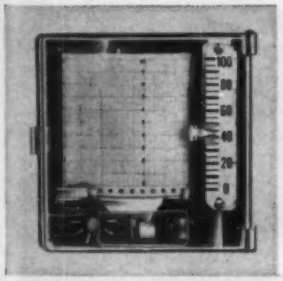
BRISTOL

TRAIL-BLAZERS IN PROCESS AUTOMATION

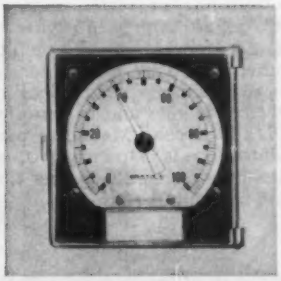
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Typical installation of Bristol Metagraphic receivers. This modern instrument installation is part of main control panel at Celanese Corporation of America's new Celanese acetate film plant at Belvidere, New Jersey. Panel designed and built by Panellit Inc., Skokie, Illinois.

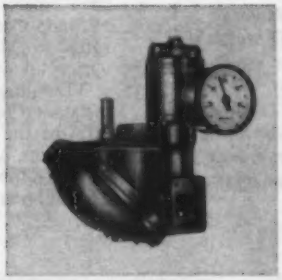
...and behind every panel, precision



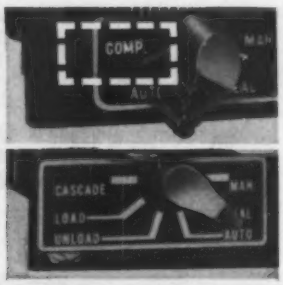
Metagraphic Recording Receiver... plugs and unplugs in 5 seconds. More than 36 pneumatic models, many electronic Dynamaster® potentiometer and bridge instruments—all with easy-to-read, human-engineered scales and charts.



Metagraphic Indicating Receiver... feature 9 inches of effective scale length, complete 10-second interchangeability with recorder of same type. Functionally colored pointers, plus long scale length makes distant reading easy.



Metagraphic Pneumatic Transmitters measure temperature, pressure, vacuum, absolute pressure, differential pressure, flow, liquid level or mechanical motion. Transmit on universal 3-15 psi pneumatic signal.



Pneumatic Control Stations allow utmost in operating flexibility. Four-position station (top) for computer-controlled refineries and chemical plants. Six-position station (bottom) for bumpless transfer in cascade systems. Many others available.

For more data on advertised products, use Readers' Service Cards, last page.

How modern refineries maintain maximum temperatures in tracer lines... without interruption

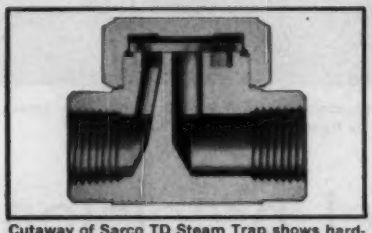
Production-Planned steam trapping insures continuous operation of process lines at design temperatures

By John W. Ritter, Test Engineer
SARCO Company, Inc.

The maintaining of design temperatures in tracer lines may appear, at first glance, to be an extremely difficult problem. Temperature, of course, must be maintained at a uniform level; but unless air and air-steam mixtures are removed from the line, design temperatures are difficult to maintain. Further, because of extremely long lines, water hammer is inherent in tracer lines.

However, if a trap is selected which operates over a full range of pressures, ambient temperatures, and loads, it will drain the tracer line automatically. For many leading refineries the new Sarco TD-50 Thermo-Dynamic Steam Trap has proved a sound solution to this problem. Dozens of refineries from New Jersey to California, from Montana to Louisiana, originally started using Sarco TD's on a test basis. After experiencing the thoroughness of their day-to-day trapping operation, these refineries standardized on TD's.

The TD-50 has excellent resistance to water hammer, and it drains air and condensate as fast as they reach the trap. This trap helps to maintain constant temperatures, and operates perfectly on variations in pressures and temperatures.



Cutaway of Sarco TD Steam Trap shows hardened stainless steel disc, which is the only moving part in the unit.

Lightness of weight and compactness of design are advantages of the TD which make it particularly valuable for use in draining tracer line tubing. The TD is easily installed and, because of its unique thermo-dynamic principle of operation, it can be installed vertically (with a free discharge downwards) in self-draining, antifreeze applications.

Some 250 Sarco Thermo-Dynamic Steam Traps are installed on the tracer lines of this new catalytic hydrodesulphurization unit at Socony Mobil Oil Company's Paulsboro, N. J., refinery.

SARCO TD-50 Steam Traps provide ideal solution to tracer line drainage at Paulsboro, N. J.

The 250 Sarco TD's used to drain steam tracer lines at Socony Mobil's Paulsboro refinery were selected for reliability. They can never "fail closed," never block heat transfer. TD's remove condensate and air as fast as they collect.

Since tracer lines are usually in exposed installations, the wide pressure range of TD's is important here. These TD's operate perfectly through a variety of weather conditions, temperature changes and load variations.

TD's have just 3 simple parts, all of stainless steel. They have high resistance to water hammer and to corrosion. They are easy to install and 90% of the TD's at Socony Mobil are mounted vertically for non-freeze operation. Maintenance is extremely low, often negative.

Write for literature today. Remember that Sarco can give you impartial advice on steam trapping because . . . 5928-B

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Only Sarco makes all 5 types:
Thermostatic • Liquid Expansion • Float Thermostatic
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  from cyclohexane
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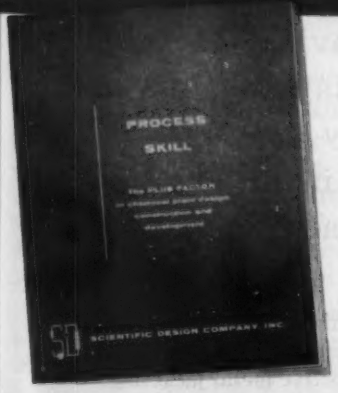
  by high pressure synthesis
- **Formaldehyde**
  from methane
- **Methyl ethyl ketone**
- **Phthalic anhydride**
- **Acetic acid**
- **Ethanolamines**
- **Ethylene oxide-glycol**
  (new 1960 model)
- **A number of other new and interesting processes and products**



NEW SD PROCESS SKILL BROCHURE Just Off the Press!

Write on your business letterhead for SD's new Process Skill Brochure. It tells why this vital PLUS FACTOR is essential in today's and tomorrow's chemical industry . . . how your company can profit by its application . . . how SD has applied its unique *chemical process skill* to chemical plant, design, development and construction throughout the world.

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Remove from carton and Metal-On is ready to install. Just snap on pipe and lock in place.

... the specially designed aluminum "snap strap" (containing vapor seal) is snapped on joint ...

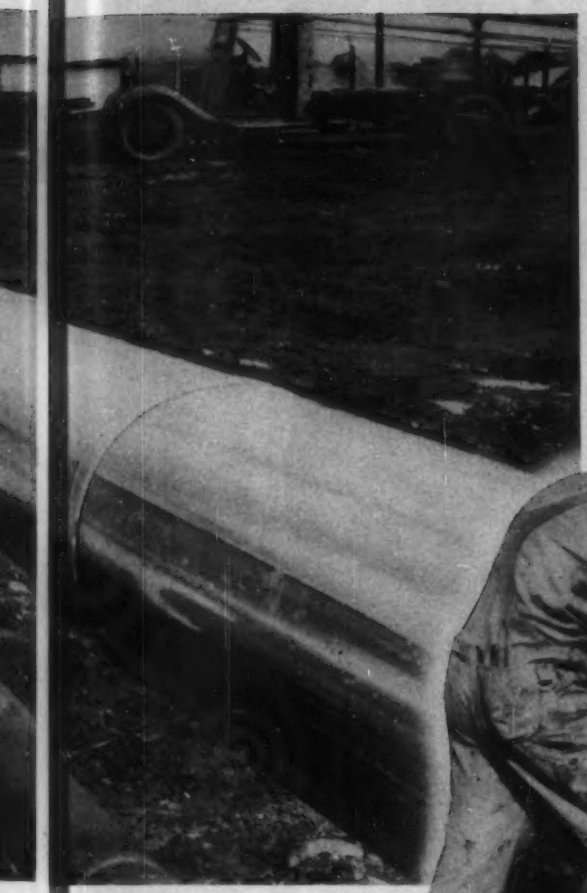
... Metal band completes the assembly ... provides perfect joint protection against vapor and weather. Available in many colors, the Metal-On band also serves color coding purposes.

Two men completed 660′ Metal-On

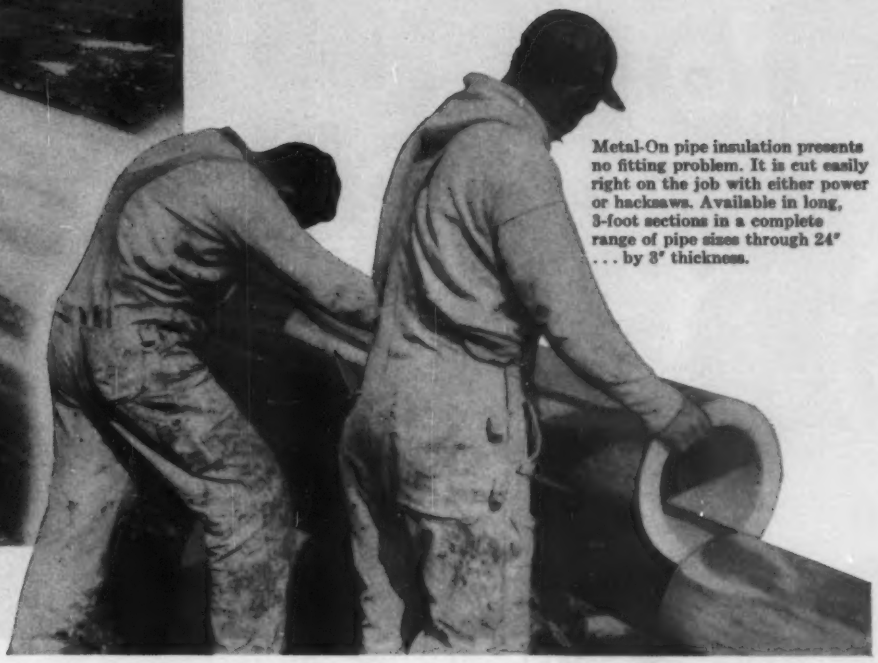
New Johns-Manville Metal-On insulation is today's fastest and most efficient way to install high-temperature pipe insulation ... and protective metal jacketing

Metal-On is still new! It is just months since its introduction—yet it has already been accepted by virtually every industry in which high-temperature pipe insulation needs protective metal jacketing.

One reason for this rapid, all-out acceptance is Metal-On's installation economy. A single package product that consists of high-temperature insulation and protective aluminum jacket—Metal-On entirely eliminates separate on-the-job metal application. In



Part of 2100-foot Metal-On installation. New plywood plant of the Winton Lumber Co., Jackson, Cal. Insulation Contractor: Western Asbestos Co., San Francisco.



Metal-On pipe insulation presents no fitting problem. It is cut easily right on the job with either power or hacksaws. Available in long, 3-foot sections in a complete range of pipe sizes through 24" . . . by 3" thickness.

this insulation job in one working day!

fact—a section of Metal-On can be applied at least as fast as pipe insulation alone.

However important installation speed may be, it is but one Metal-On advantage! For Metal-On also ends guesswork in specifying aluminum alloys and jacket thicknesses. Its jacket measures an ideal .016" thick . . . of a high-quality aluminum alloy selected expressly for superior weather resistance . . . good appearance . . . and resistance to abuse and pitting.

Of course, Metal-On never needs painting. Won't rust. Is impervious to dirt, oils and grime. And, unlike corrugated metal jacketing, Metal-On has no dirt-collecting grooves—its smooth surface stays clean.

Metal-On also provides top fuel savings and accurate temperature control, because its insulating element is Johns-Manville Thermobestos®, finest of all the calcium silicate insulations for temperatures to 1200F. The conductivity of Thermobestos is lowest of all insulations generally used in power and process industries.

To help you compare Metal-On with the insulation you're now using—let us send you the new technical data brochure, IN-217A. Write for it today. Address Johns-Manville, Box 14, New York 16, N.Y.

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● Your profit picture begins with the design and engineering of your plant. It is the purpose of the McKee organization to see that it doesn't end there.

Sound engineering before the first shovelful of dirt is turned can mean initial savings in construction and repeated savings in plant operation—savings that go on year after year.

The experience and skill demonstrated by McKee engineers in steel, petroleum and chemical plant design and construction totaling more than $1½ billion promises a cost-cutting, efficient operation. If you have plans for such construction McKee has the key for you.

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Arthur G. McKee & Company can supply engineering design and construction for these petrochemical processes:

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- Hydrogen Sulfide
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- *P*-Cresol
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- Polyvinyl Chloride Resin
- Propylene
- Propylene Tetramer
- Sulfur
- Sulfuric Acid
- Vinyl Resins

Arthur G. McKee & Company, in association with the Hoechst-Uhde Corporation, can supply licensing, process know-how, engineering design and construction for these processes:

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- Polystyrene
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SCHEDULES 5 AND 10	SCHEDULES 10 AND 40	AND OTHER ALLOYS

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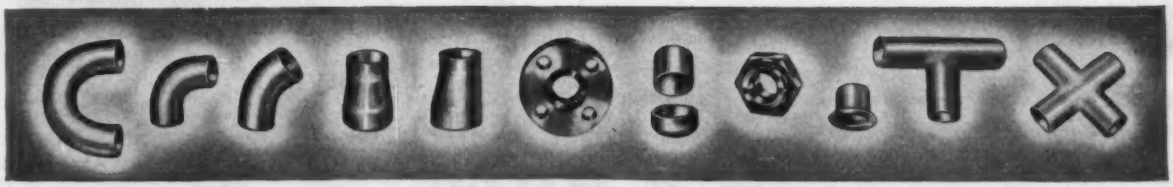

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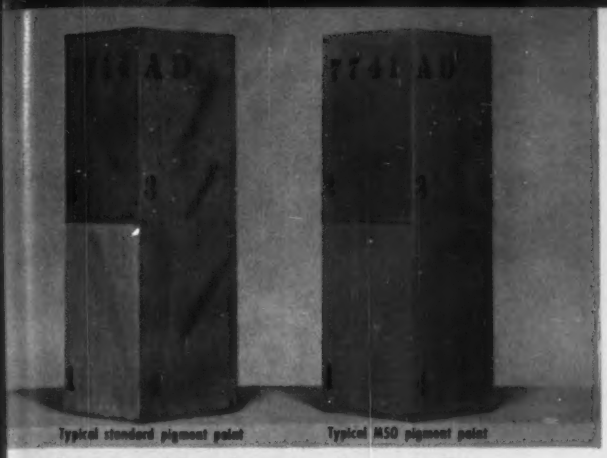
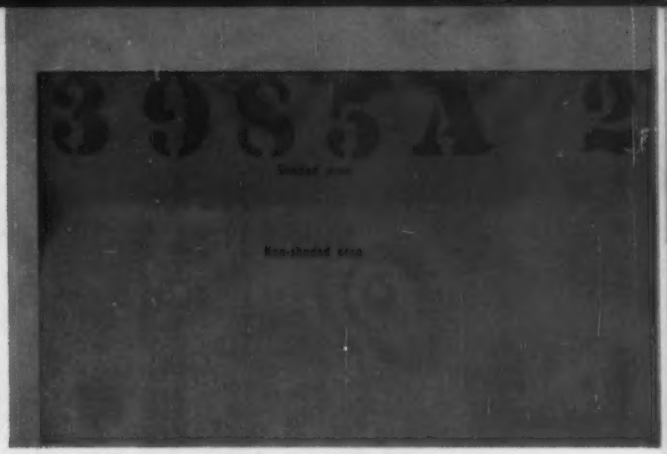


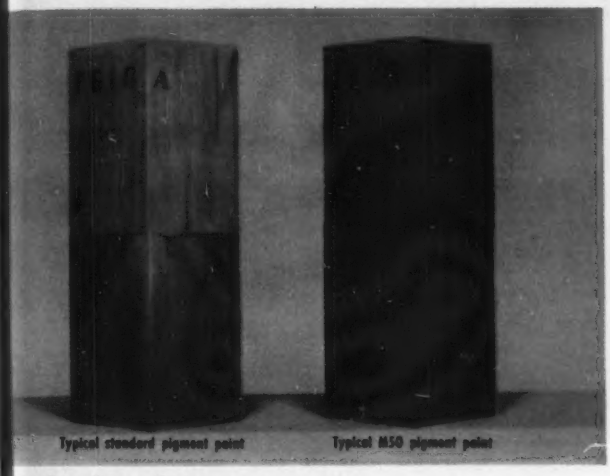
No objectionable whitening from chalking

Contrast these two exposure test panels . . . both show comparable metal finish paints. Same original colors. Same exposure (45° South, 2 yrs., 3 mos.). Notice bright color of *M50* paint, freedom from chalk.



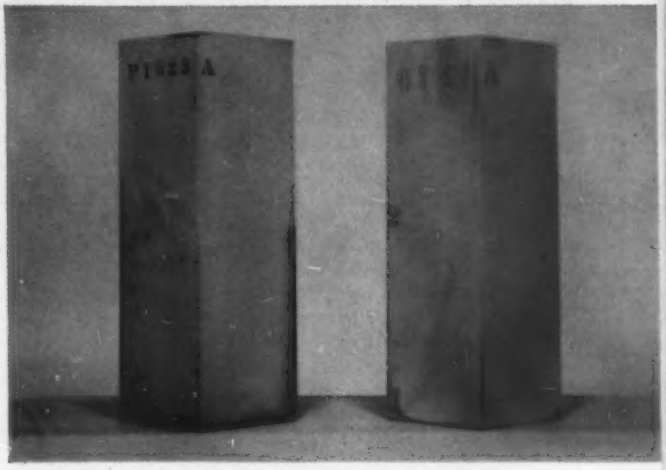
No appreciable fading from light action

Now look at this 9-year exposure test panel of an *M50* paint. Contrast area shaded by wooden panel holder with non-shaded area. Clearly, there has been practically no fading in this 9-year period.



No leaching from water action

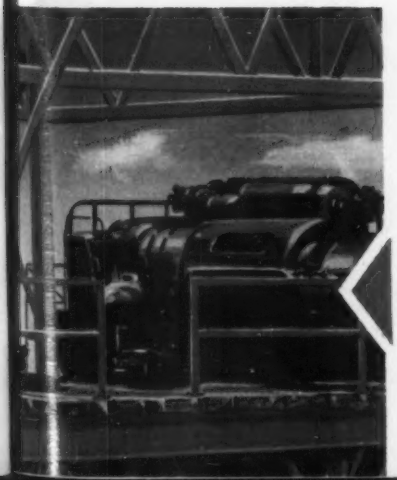
Examine the exposure panel at left. Notice the vertical brushmarks? Rain water leaching of the top coat permits brushmarks in undercoat to show through. In the panel at right, insoluble *M50* pigment prevents this film failure. Exposure 45° South, 2 yrs., 7 mos.



No discoloration in industrial atmosphere

Here are two exposure panels painted from the same can of *M50* paint. Both have been exposed 4 years, 45° South. The right one in normal atmosphere, the other in sulfur-laden industrial atmosphere. Notice no color difference has developed. No bilging.

Proof you get unique color stability in metal protective paints made with M50® pigment



Drilling equipment looks better, needs less maintenance painting when painted with colorful *M50* anti-corrosion paints.

No need to amplify what the four illustrations above show. Plainly, *M50* basic lead silico chromate pigment permits your paint supplier to make paints with more color stability than ever before available in anti-corrosion paints . . . primers as well as finishes.

National Lead exposure tests demonstrate that these paints . . . both standard and heavy coat . . . also provide better and longer lasting anti-corrosion action, and never-before weather resistance. Some of the opportunities these new *M50* paints present are suggested on the following page. You'll think of others.

M50 pigment is a product of **National Lead Company**

Public relations.
Attractive tank farms that *stay* attractive longer.

Product identification.
Color-coded drums that *stay* colorful longer.

Two ways to make good use of the superior color stability of M50 pigment anti-corrosion paints

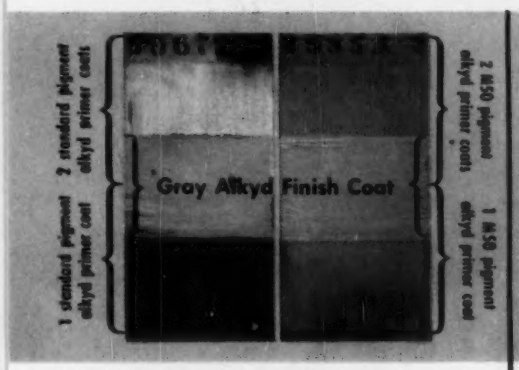
Before the advent of *M50* pigment, those responsible for maintenance painting had to make a choice between colorful appearance and long-lasting corrosion protection.

With *M50* pigment paints, exposure experience proves, this compromise is no longer necessary. *M50* paints have weather resistance . . . stay bright and colorful . . . and *at the same time* provide superior corrosion protection. With these unusual paints, color stability problems . . . leaching, fading, whitening, darkening from bilging . . . are eliminated. Now, with *M50* paints, you can have maximum anti-corrosion, maximum durability and, at the same time, long-lasting good appearance.

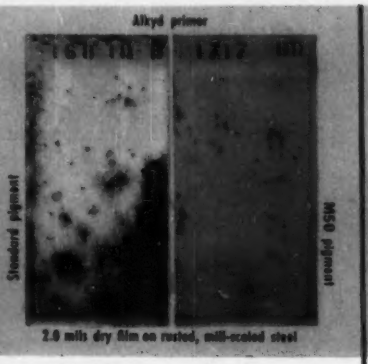
The illustrations above suggest two areas in which the combination of superior anti-corrosion action and superior color stability found in *M50* pigment paints can pay off handsomely. Note that in both, service is severe and colorful colors are needed. With *M50* paints, you repaint less often.

In your own operations there are bound to be many similar applications where specification of *M50* paints can lower your maintenance painting costs. Ask your regular paint supplier to make up suitable *M50* paints for your requirements.

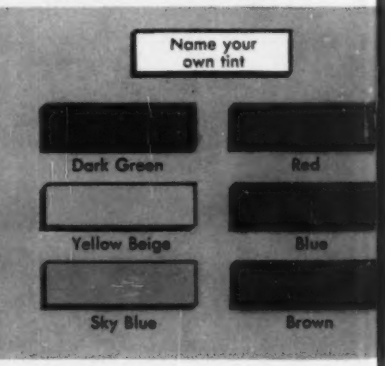
Why M50 Defense in Depth paints give anti-corrosion beyond all former concepts


2 standard pigment alkyd primer coats
2 M50 pigment alkyd primer coats
Gray Alkyd Finish Coat
1 standard pigment alkyd primer coat
1 M50 pigment alkyd primer coat

Exposed 9 years, 45°S. Each coat 1.5 mils
Proved corrosion and weather resistance



Exposed 45°S; 1 yr ind. atmos, 1 yr normal atmos.
Proved outstanding for film strength, durability



Colors above available in conventional and heavy-coat paints
A wide range of stable colors can be produced

Are you concerned with tank or structure maintenance painting in your firm? If so, you are invited: (1) to visit National Lead's Sayville, L.I. test station, where you will see the results of the 20 years research that lies behind the *M50* pigment particle and the more than 10 years of exposure testing that lies behind *M50* pigment Defense in Depth paints; (2) to send coupon below for National Lead booklet, "Defense in Depth" and typical *M50* tank paint specifications.

Next time you purchase, specify *M50* pigment paints. Any paint manufacturer can supply you.

M50 Defense in Depth

National Lead Company,
111 Broadway, New York 6, N. Y.

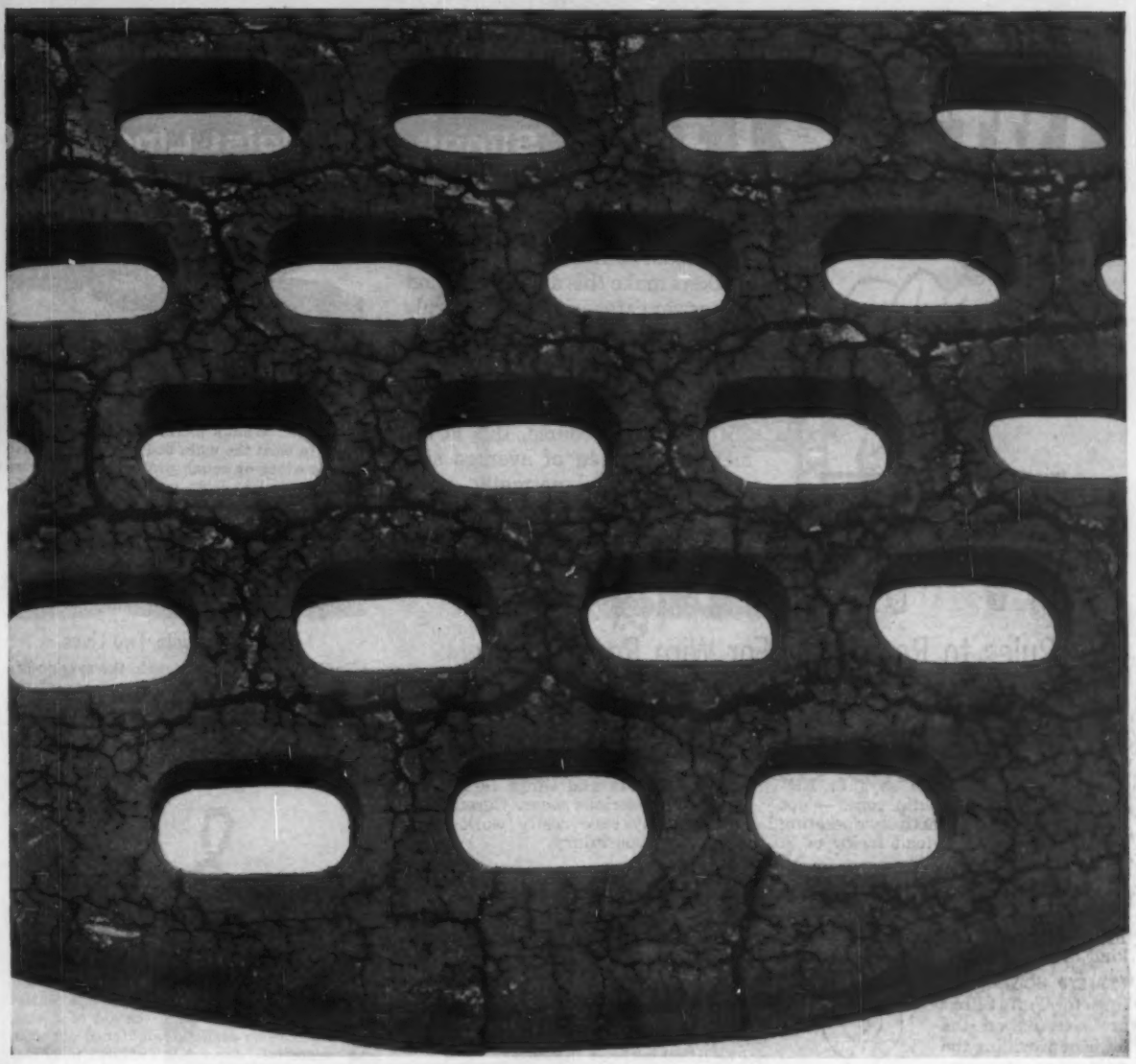
Gentlemen: Please send me the "Defense in Depth" booklet together with typical tank paint formulas and color chips that I can use in specifying M50-type tank paints.

Name_____ Title_____

Firm or Dept._____

Address_____

City_____ State_____



This is THERMAL FATIGUE

This photograph shows a heat-resistant alloy casting after thermal-fatigue failure.

Thermal fatigue begins with cyclical heating and cooling which produces alternate expansion and contraction. The shape of the casting hinders this expansion and contraction. As a result, hindered expansion and contraction stresses develop and increase until plastic flow occurs. This plastic flow produces a network of thermal-fatigue cracks and this cracking leads to failure.

Thermal fatigue is an inherent problem in heat-resistant castings. As such, it occupies an important place in Electro-Alloys research efforts to lengthen life of components working under high temperatures and severe cyclical conditions.

We have created apparatus that assesses and analyzes the variables of thermal fatigue. Check with your Electro-Alloys representative for the meaning of our thermal fatigue data as it pertains to the material, design and service conditions of your heat-resistant castings.

Send for free technical booklet on Thermal Fatigue

Please send me free copy of "The Mechanism of Thermal Fatigue," by Howard S. Avery—comprehensive report based on extensive lab studies:

Name_____

Title_____

Company_____

Address_____

City_____ State_____

Electro-Alloys, 10311 Taylor St., Elyria, Ohio

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION • Elyria, Ohio

For more data on advertised products, use Readers' Service Cards, last page.

Tuffy Tips —on safe use of Slings and Hoist Lines

How Much Lifting Should be Done by Muscles?

Individual differences between workers make this a hard question to answer categorically. For a rule of thumb: the United States Department of Labor recommends men should handle no more than 50 pounds; women no more than 25 pounds. Of course, this is for men and women of average size and weight, in normally good physical condition. To remove all doubt, mechanical lifting and hoisting equipment should be used for all loads not comfortably lifted by muscles.

Rules to Remember For Wire Rope Safety

1. **BREAK IN** new wire rope with care. Don't use it at maximum load capacity until it is broken in beyond a doubt.
2. **OBSERVE SAFETY FACTORS.** Usually the rated load factor is 4 to 5. The Wire Rope Technical Board says 5. Elevators require 10. Static ropes — not hoisting, dragging or actively operating —may have a rated load factor of 3.
3. **LUBRICATION IS IMPORTANT** for safety, as well as for pliability and friction-fighting. Rust makes ropes brittle, and likely to break without warning. Thorough lubrication keeps out rust.
4. **INSPECT ROPES** and slings frequently for signs of serious wear. Careful inspection may save costly work stoppage or serious injury.

Sling Fittings Are Important Safety Aids

Proper fittings serve the dual purpose of greater safety and longer sling life. Fittings used on Tuffy Slings are made in more than a score of types, for every kind of service. Two of them are shown here:

(1) **EYE HOOKS:** Fittings for Tuffy Slings are selected on the basis of providing the complete unit assembly with equal breaking strength overall. Eye hooks are forged steel, weldless and designed for efficiency.

(2) **NEWCO SAFETY HOOK:** People can forget to lock a hook gate. This safety hook always remembers. A load cannot be lifted without the gate (yoke) automatically locking. To be opened, it must be manually pressed against a compression spring. We also supply this safety hook with a swivel eye for the sling. The name: Newco Safety Swivel Hook.

Tuffy Hoist Line: Stalwart Companion of Tuffy Slings

Tuffy Slings and Hoist Lines work as an efficient team on all types of overhead cranes, derricks and clamshells. Like all Tuffy Special Purpose Wire Ropes, Tuffy Hoist Line has the

right combination of strength, flexibility and toughness for greatest safety and longest service life. Use this Tuffy "team" to cut hoisting costs in every type of materials handling.

Your Tuffy Distributor Offers the Most in Service and Savings

An Eye for Strength and Safety

Slipped over the tuck-splice of the sling eye, and pressed on under tremendous hydraulic pressure, the steel ferrule holds so tight that it gives the eye splice full strength of the fabric. What's more, it is smoothly tapered to meet the main body of the sling. No abrupt edges or rough projections to injure hands and slow down work. The extra life, efficiency and safety of Tuffy's pressed-on ferrule is yours at no extra cost.

Tuffy Leads with Two Lives

"Tuffy Slings give us double the service life of ordinary slings." So reported one of the big steel corporations. The secret of Tuffy's extra life: the patented 9-part machine-braided fabric. It provides a combination of flexibility and strength never possible with ordinary wire rope.

Tuffy Takes the Danger Out of Kinks

In the first place, Tuffy Slings are not likely to kink at all. Try to kink a Tuffy. Even if you succeed with the aid of a vise, the kink can be easily straightened out with no material damage. Tuffy's machine-braided fabric won't take a "set" or deformity under the toughest of ordinary working conditions. So the danger of rope-weakening kinks is eliminated.

FREE! New Tuffy Sling Handbook

Revised and enlarged edition of famous sling manual. Covers all the bases in selection and use of Tuffy Slings and sling fittings. Gives types, dimensions, weights and rated loads. Even includes safety-approved standard signals used in operation of various equipment. Send for your free copy now. Write **Union Wire Rope Corporation, 2284 Manchester Ave., Kansas City 26, Mo.**

. . . Specialists in high-carbon wire, wire rope, braided wire fabric and stress relieved wire and strand.

UNION Wire Rope

S1

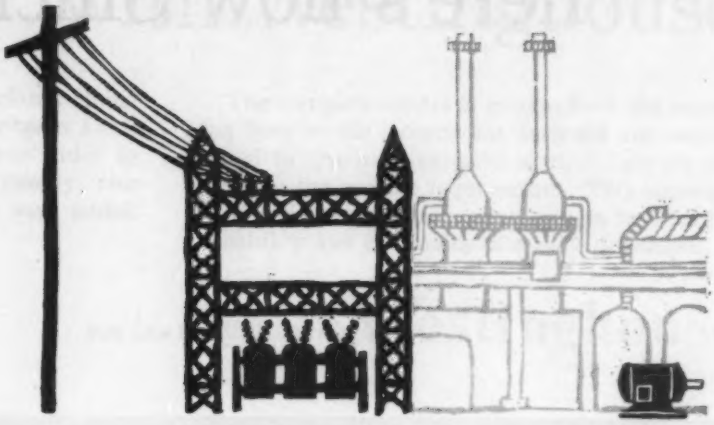
Subsidiary of ARMCO STEEL CORPORATION

OTHER SUBSIDIARIES AND DIVISIONS: Armco Division • Sheffield Division • The National Supply Company
Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Southwest Steel Products

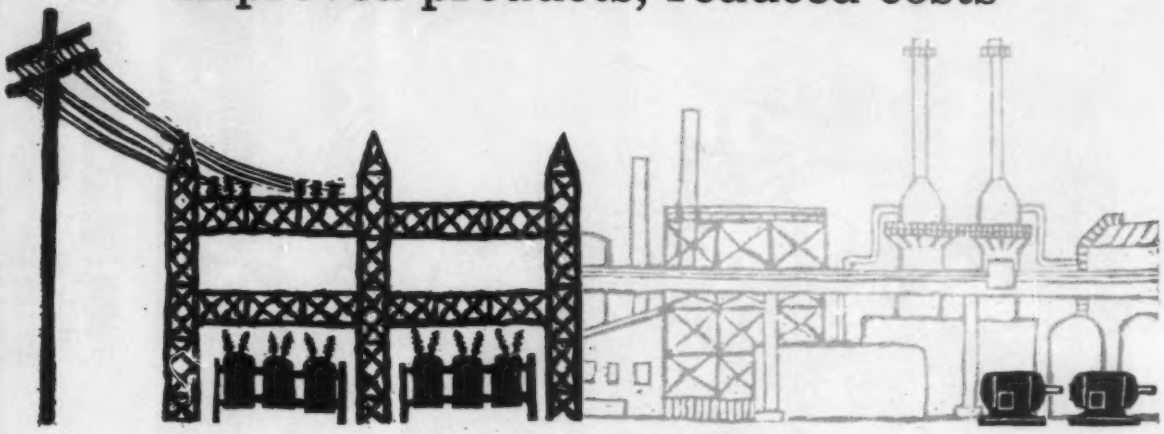
New steels are born at Armco

plan now to

POWER-UP FOR PROFIT ELECTRICALLY



Sinclair Refining did: increased production, improved products, reduced costs



When Sinclair Refining modernized and expanded their Houston refinery, production increased and product quality improved. All this was accomplished through a carefully planned Power-Up program. The reliability of present-day electrical equipment and power supply minimized the amount of stand-by equipment needed.

You will need more capacity to meet the 40% increase in demand for goods by 1965. Be sure that your electrical equipment is engineered to produce earnings as well as output. See how Westinghouse helped Sinclair Refining to Power-Up.

YOU CAN BE SURE...IF IT'S Westinghouse

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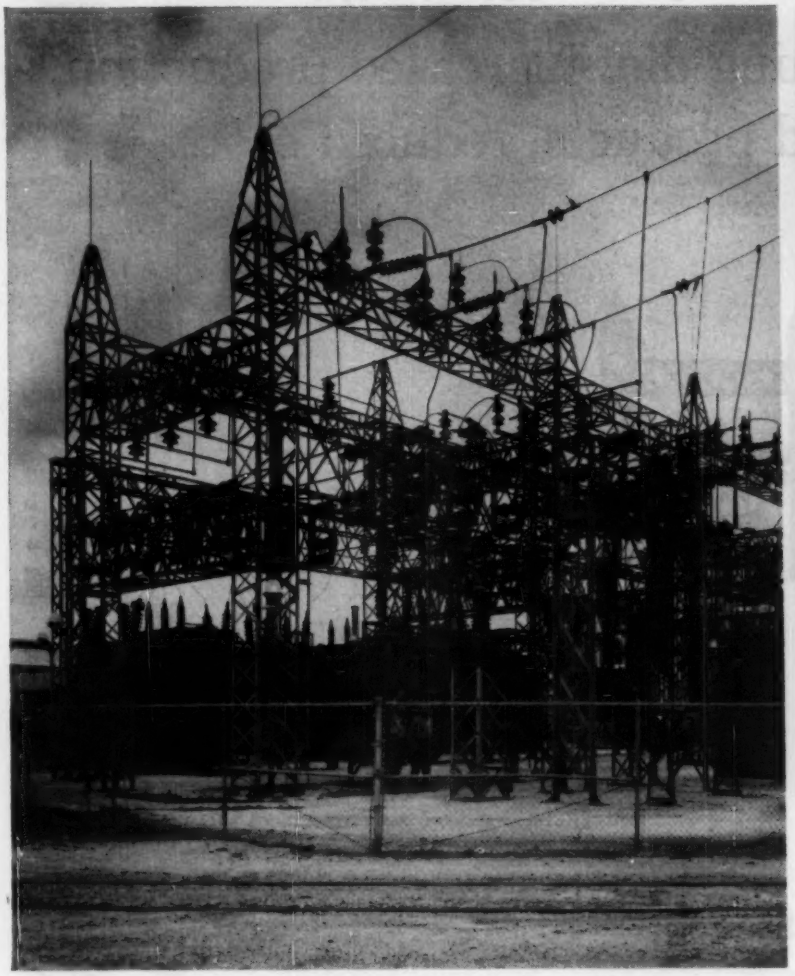
here's how Sinclair Refining



Main substation with two incoming 66-kv power lines is equipped with Westinghouse switchgear and transformers. Continuity of service is assured through the use of this dual feed to the refinery.

Relaying panels for protection of two incoming 66-kv lines, showing pilot wire and associated relays. These high-speed relays provide superior circuit protection by minimizing equipment damage and provide service continuity.

For more data on advertised products, use Readers' Service Cards, last page.

POWERED-UP with Westinghouse

Expansion and modernization at Sinclair's Houston refinery were carried out in two phases. Initially, a fluid catalytic cracking unit was added to expand the plant's capacity. Subsequently, two HDS (Hydrodesulphurization) units were added to improve the product quality.

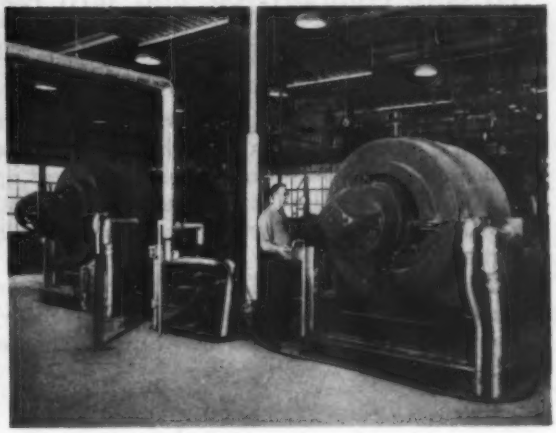
The complete electrical system from the incoming lines to the motors was designed and coordinated to give an integrated electrical supply tailored to the specific requirements. This approach provided the most economical system to meet the reliability and continuity of service demanded.

J-06131

YOU CAN BE SURE...IF IT'S **Westinghouse**

Unit substation with three 5000-kva transformers. Availability of alternate transformers and breakers provides the ultimate in reliability.

The refinery is served by three power transformers through three outdoor high-voltage switchgear assemblies interconnected by tie bus. Protective relaying system permits fast change-over, insures service even with power interruptions.



Large Westinghouse synchronous motors with Therma-lastic® insulation which assures trouble-free operation and longer life. They are driving cooling water circulation pumps.

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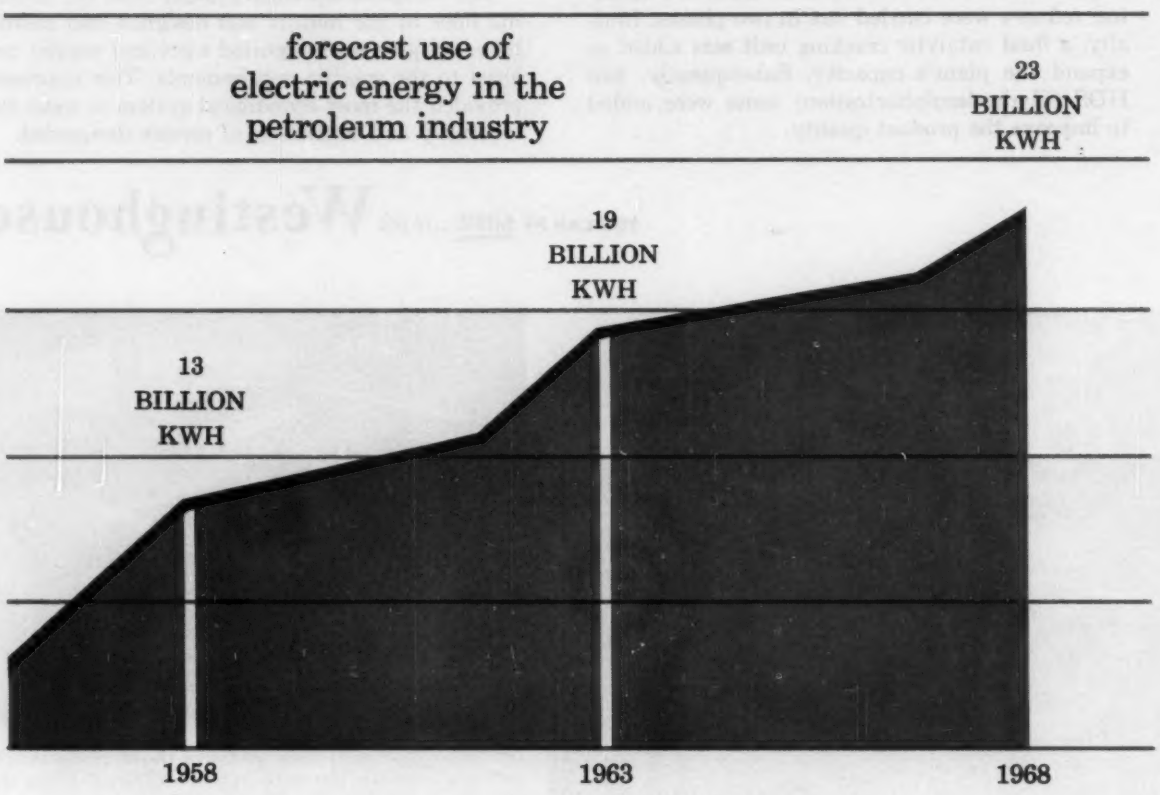
here's why you should plan now to
POWER-UP FOR PROFIT ELECTRICALLY



To stay competitive, you will be investing in a tremendous increase in electric power equipment. Be sure it is engineered to produce profits.

Greater use of electrical energy and up-to-date electrical equipment can help you get a better return on your investment through improved operations. In your plant it may be higher capacity machinery, more efficient equipment, or specially engineered controls.

Whatever the need, maximum use of low-cost kilowatthours can help you earn satisfactory profits. Your plant will need more capacity to meet the forecast 40% increase in the demand for goods by 1965.

Be sure—like Sinclair Refining—that your electrical equipment is engineered to produce earnings as well as output. Call your Westinghouse representative or your electric utility power sales engineer. They can tell you the electrical steps you can take *now* to start a Power-Up program in your plant. J-96131

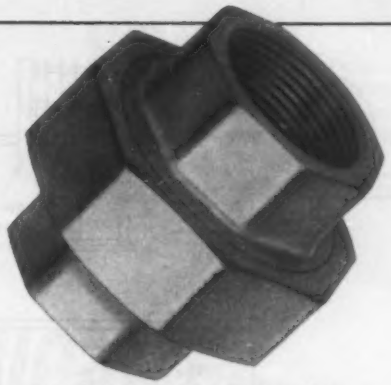
YOU CAN BE SURE...IF IT'S **Westinghouse**

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV FRIDAYS

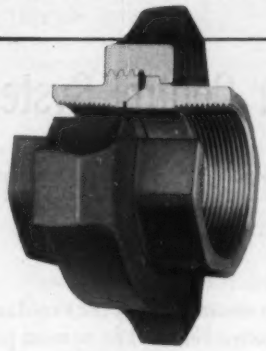
Add Life to Your Lines

with Rockwood Cold Forged STEEL UNIONS

Longer service life under severe line conditions is only one of many extra-performance features you get with Rockwood Unions. Stronger and tougher, they're built to take it under shock, constant vibration, expansion, and rough handling with wrenches. What's more, they are 100% inhibited against corrosion (threads are Rockwoodized — seats made of non-corrosive materials). Exclusive choice of 4 different seats to cover all your piping needs . . . 1. Silicon Bronze 2. Stainless Steel 3. Moly Steel 4. Moly to Silicon Bronze. Be sure right down the line—with Rockwood Unions. Send coupon today.



ROCKWOOD DUALSTEEL UNION
Solid constructed union of special alloy steel. Eliminates the galling usually inherent in solid steel constructed unions. Resists severe mechanical abuse. Gives maximum protection against corrosion.



ROCKWOOD "TRI-LUG" UNION
Has special alloy nut with speed threads . . . one of three lugs is always in position to make union up or break apart fast, even in tight spots.

ROCKWOOD SOCKET WELD UNION
2 Moly Steel seats with Hardness Differential . . . specially reamed for socket welding. Sizes ¼" to 2" inclusive. Meets A.S.A. specifications.

ROCKWOOD "BALANCED DESIGN" gives all three parts of union equal strength for greater resistance to tough working conditions. Complete interchangeability of parts permits quick economical replacement.

COLOR-CODING MAKES IDENTIFICATION FAST AND POSITIVE!

GRAY NUT — Type 601 with Silicon Bronze Seats.	**OLIVE DRAB NUT** — Type 603 with Moly Steel Seats.
BLACK NUT — Type 602 with Stainless Steel Seats.	**GRAY NUT** — Type 604 with Moly to Silicon Bronze Seats.

ROCKWOOD SPRINKLER COMPANY

Distributors in all principal industrial areas

ROCKWOOD SPRINKLER COMPANY
725 Harlow Street
Worcester 5, Massachusetts

Please send me more information on Rockwood Unions.

Name .....

Title .....

Company .....

City ..... *Zone* .... *State* .....

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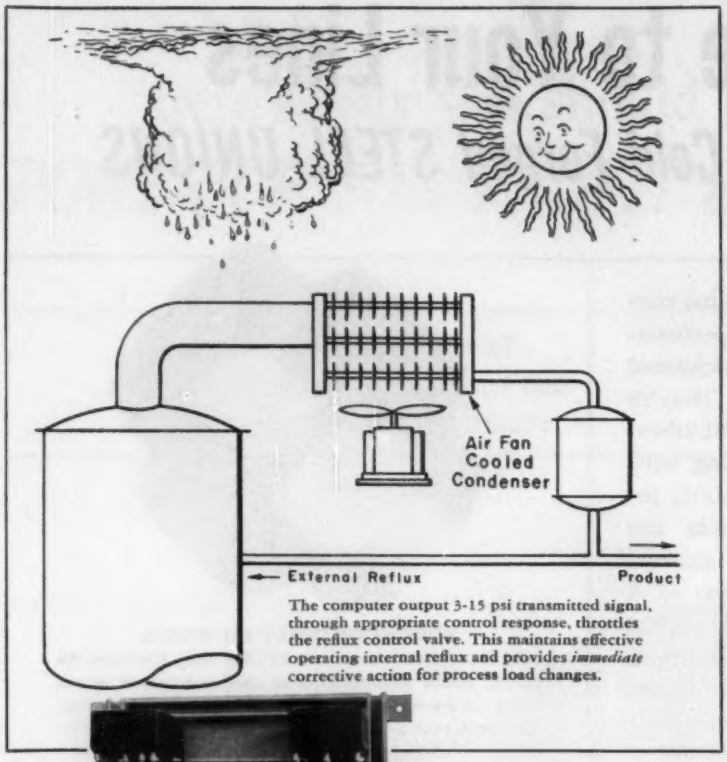
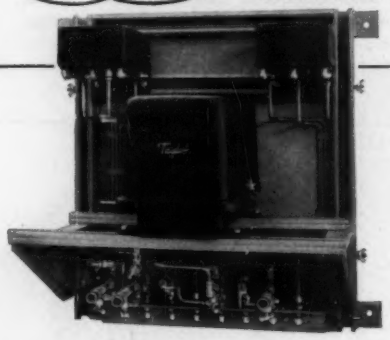


The computer output 3-15 psi transmitted signal, through appropriate control response, throttles the reflux control valve. This maintains effective operating internal reflux and provides *immediate* corrective action for process load changes.

FOR CONSISTENT COLUMN EFFICIENCY

...rain or shine



New Taylor Computer Control System Used by Phillips Petroleum Company

PROBLEM: Column upsets, caused by wide variations in load on the condenser due to changing weather conditions. Efficiency is reduced . . . more steam than necessary is used in reheating excessive reflux.

SOLUTION: A simple Taylor Computer Control System which instantly compensates for climatic effects on air-cooled condensers and reflux lines. This system is developed by and is licensed by Phillips Petroleum Company.

RESULTS: Phillips is delighted with the outstanding performance of this system, in commercial use on many columns. Phillips' engineers like its simplicity, and the fact that components are of the standard type with which its instrument people are accustomed. Here are some of the advantages of the Taylor Computer Control System:

1 It reduces steam consumption by the avoidance of reheating excessive reflux. The system pays for itself in a few months.

2 It provides more uniform products by smoothing out upsets at their source—particularly important on a battery of columns.

3 Not only does it give vastly improved control on columns utilizing air-cooled condensers (without the need for adjustment of air flow rate), it also pays out with other types of condensers.

4 It reduces the possibility of column flooding.

* * *

Call your Taylor Field Engineer today, or send for literature. Taylor Instrument Companies, Rochester, N.Y., or Toronto, Ontario.

Taylor Instruments **MEAN ACCURACY FIRST**

SOLVAY TECHNICAL AND ENGINEERING SERVICE
Bulletin No. 15
First Edition—1st Printing 1959
CAUSTIC POTASH
Contains properties of caustic potash and its solutions . . . data on unloading, handling, dissolving . . . conversion tables . . . wall chart of handling precautions.
Features vital facts, tables, diagrams for applying caustic potash with maximum effectiveness and safety!
Announcing!
NEW SOLVAY TECHNICAL BULLETIN
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This basic reference work includes recognized source material.

Now America's foremost producer of alkalies—Solvay—brings you an authoritative, helpful source-book of the latest information on caustic potash. And it's a *completely new* addition to your Solvay reference library . . . in the great tradition of Solvay Technical and Engineering Service Bulletins.

Fill in the coupon for your copy, and indicate any other Solvay technical bulletins you might find useful.

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SOLVAY® branch offices and dealers are located in major centers from coast to coast.

SOLVAY PROCESS DIVISION
ALLIED CHEMICAL CORPORATION
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Please send me without cost your new Bulletin 15, Caustic Potash, as well as the other Solvay bulletins checked below.

- ☐ #4—Calcium Chloride in Refrigeration
- ☐ #5—Soda Ash
- ☐ #6—Caustic Soda
- ☐ #7—Liquid Chlorine
- ☐ #8—Alkalies and Chlorine in the Treatment of Municipal and Industrial Water
- ☐ #9—The Analysis of Alkalies
- ☐ #11—Water Analysis
- ☐ #12—The Analysis of Liquid Chlorine and Bleach
- ☐ #14—Chlorine Bleach Solutions
- ☐ #16—Calcium Chloride

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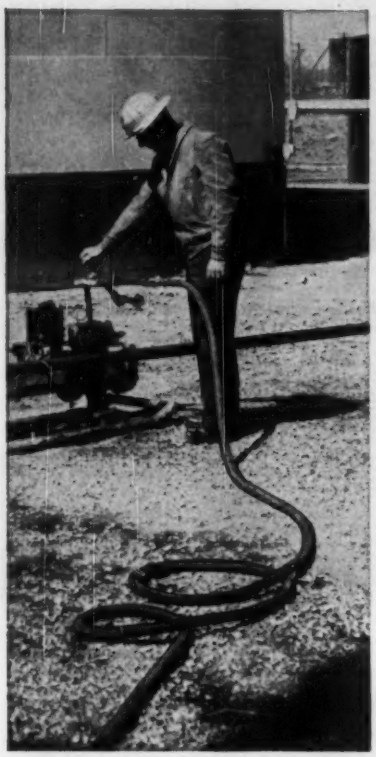
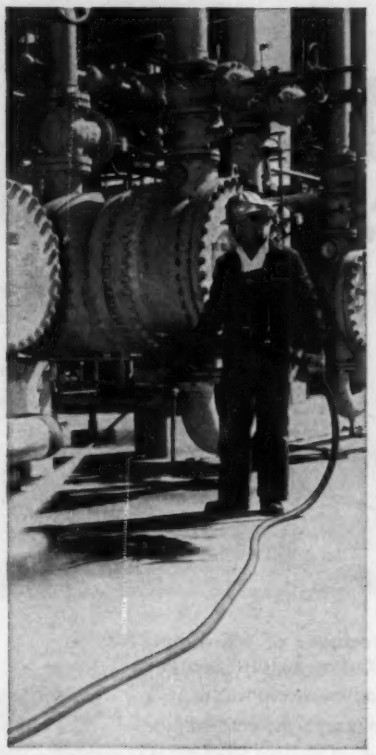
MATCHLESS #5 STEAM HOSE

3 Men . . . 3 Applications
One Hose



Safety
U. S. Matchless #5 Steam Hose has been used at a Phillips Petroleum refinery* since 1930, for thawing and firefighting.



Easy Handling
Here U. S. Matchless #5 is being used to remove spilled oil.

Economy
Warehouse boss at Phillips Petroleum inspecting a length of U. S. Rubber Matchless #5 Steam Hose.

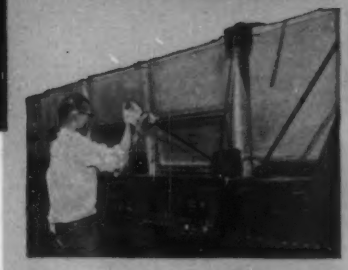
Men like to work with U. S. Matchless® #5 because it's so lightweight, so flexible. Ordinary hose is hard to handle, can't take much dragging around. But the hose that's readily available, lasts longer, and satisfies the operators is the best investment. That's U. S. Matchless.

When you think of rubber, think of your "U. S." Distributor. He's the best on-the-spot source of technical aid, quick delivery, and industrial rubber products.

*Okmulgee, Okla.

Mechanical Goods Division
United States Rubber
WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS
Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

newest Westvaco "first" saves money for Ba users!



Illustrations show 5,000 lb. capacity bins being loaded on flat car. Bins have feet which fit in slots to hold them securely in place. When car is fully loaded, cables are tightened and it's ready to roll.

Like many other Westvaco customers, you might be able to realize substantial savings on barium chemicals in these easy-handling, moisture-tight shipping and storage bins. Your nearest Westvaco office will gladly assist in estimating the possible economies in terms of your specific operation.

This modern, money-saving package is the most recent in a series of customer-minded product and service innovations in Westvaco Barium that result from our years of experience.

Through the years we have cooperated with lube oil and other barium users to pioneer new products best suited to their needs. As a result, we offer the widest range of barium products made, backed by fully integrated production and an unmatched record of dependability.

fmc
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Putting Ideas to Work

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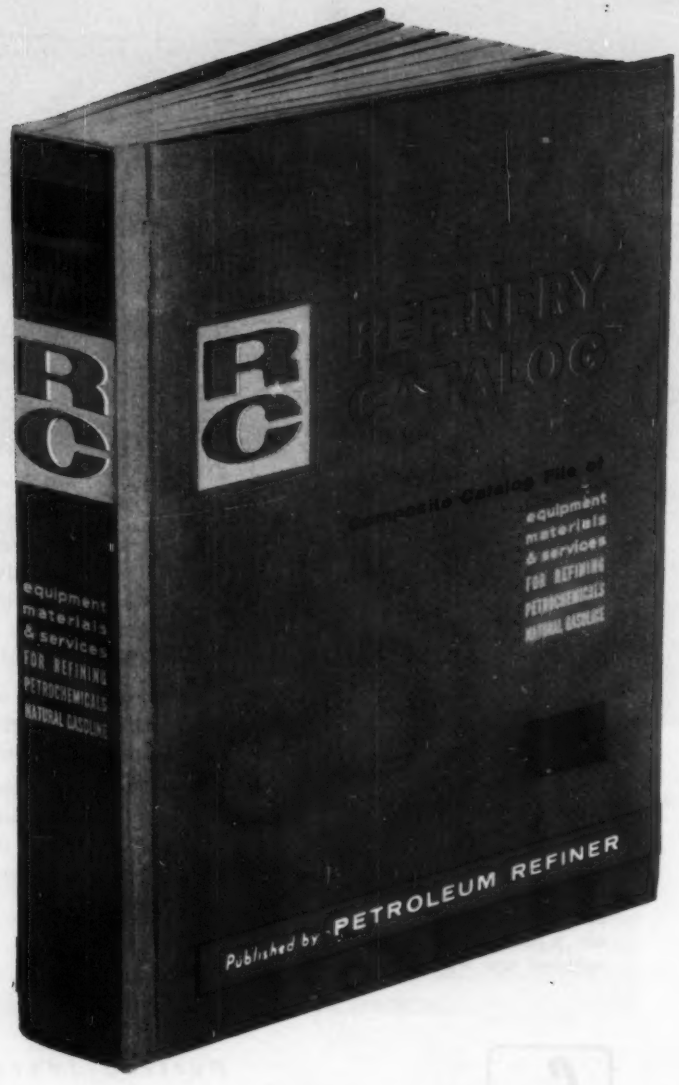

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Here's Why Oil Men Specify
EC&M HIGH VOLTAGE STARTERS

EC&M Type ZHS Starters at Southwestern pipe line trunk station

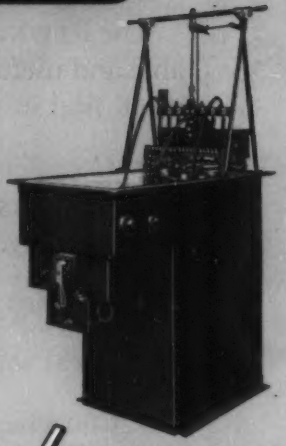
Designed for Easier Installation, Inspection and Maintenance

Specifically designed for Class I, Group D, Division 2, semi-hazardous locations . . . NEMA 3R (raintight enclosure). 50,000 KVA interrupting capacity.

***Fast* installation** because starters are shipped with all internal wiring complete. All leads are of anti-syphon construction.

Easy inspection • Contactor and overload relay panel may be raised, as one unit, above oil level. No disconnecting of bolts or leads. *(See lifting mechanism at extreme right.)* Safer, too . . . note view windows on each side of load-break disconnect switch.

View from above shows complete internal wiring . . . anti-syphon leads. These "ready-to-use" starters are complete with control transformer for 220 volt push button operation.



EC&M Contactor lifter raises contactor and overload relay above oil level for easy inspection. No bolts or leads to disconnect.

For literature describing EC&M's complete starter line, write for Bulletin 8131-T

THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
CLEVELAND 28 • OHIO

8020

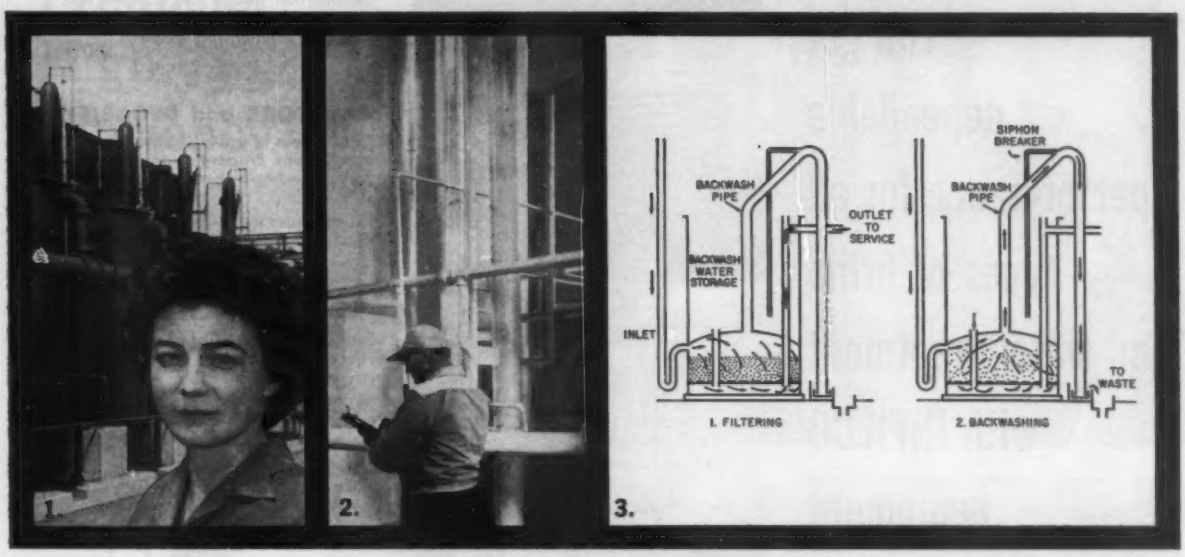
FLUIDICS

is a Pfaudler Permutit program providing
the know-how
the equipment
and the experience
for solving problems involving fluids

FLUIDICS covers such varied phases of fluid handling and control as:

waste treatment
water treatment
corrosioneering
reactions
polymerization
ion exchange
fluid analysis, metering and control
agitation
evaporation
distillation
drying
blending
metering
valving
flow rate control
piping
storing
centrifuging
filling
heat transfer, etc.

Whenever you have a fluid-handling problem, look to the Pfaudler Permutit FLUIDICS program for the best solution.



FLUIDICS AT WORK

New valveless filter costs up to 45% less than conventional gravity designs

Here's a completely automatic filter that saves you up to 45% on initial cost and then goes on to save more during operation.

1. One girl does the work of three husky men at the West Virginia Pulp and Paper Company plant in Charleston, S. C., where Permutit valveless filters were installed. No crew is needed to open and close heavy valves for shutoff, backwash and rinse.

2. "No maintenance or operating expense with our Permutit valveless filters," is the report from O. M. Scott & Sons chemical products plant in Ohio. These filters use no expensive valves, flow controllers, pumps, or hydraulic or pneumatic control systems.

3. Permutit valveless filters are completely automatic. They shut themselves off from service at just the right bed condition. They backwash and rinse at the most efficient flow rates and for pre-set lengths of time. Then they put themselves back into service.

For details write for our Bulletin 4351. Address your inquiry to our Permutit Division, Dept. PR-119, 50 West 44th Street, New York 36, New York. In Canada write to the Permutit Company, Room 505, 207 Queen's Quay West, Toronto 1, Ontario, or 207 West Hastings Street, Vancouver 3, B. C.

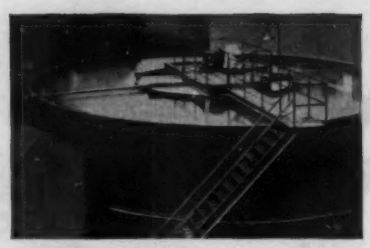
PFAUDLER PERMUTIT INC.

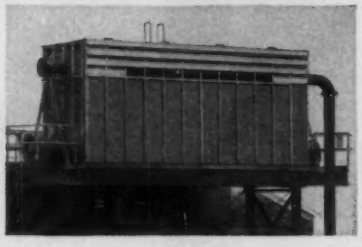
Specialists in FLUIDICS . . . the science of fluid processes

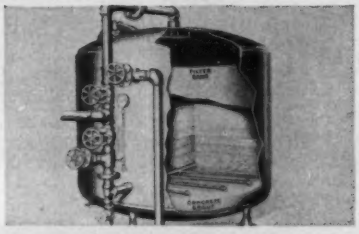
For more data on advertised products, use Readers' Service Cards, last page.

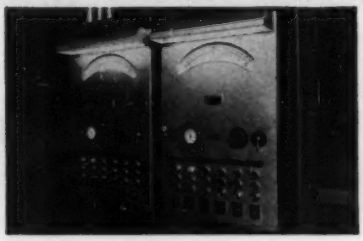
You get dependable performance for all types of brine and water treatment with INFILCO equipment

INFILCO









ACCELATOR®
plants for clarification, softening and stabilization
Effective mixing of chemicals and raw water with recirculating slurry and downflow separation effect better treatment in minimum area — and at low cost. For water, brine or waste treatment. BULLETIN 1825

CHEMICAL FEEDERS
Accurately controlled feed rates and maximum economy
Compact designs for automatic or manual control, for all types of chemicals. Type E Feeders dispense dry chemicals volumetrically, from bulk storage to dry or wet applications. BULLETIN 215

NEUSOL® FEEDERS
Wide feed range, corrosion resistant construction adapt this versatile and dependable displacement feeder to most chemical solution requirements. BULLETIN 340

AERATORS and DEGASIFIERS
For all types of gas-liquid transfer applications. Efficient oxidation, carbon dioxide and hydrogen sulfide removal. BULLETIN 106
Request information on recarbonators, deaerating heaters and vacuum degasifiers.

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Standard or special construction for the most exacting process requirements
Vertical or horizontal, sand or anthracite types with manual or automatic controls for water or brine filtration. BULLETIN 1520
The STELLAR® diatomite filter, with its exclusive "gas-bump" cleaning is standard for amine solutions in most of the largest gas companies. BULLETIN 1560

MODERN INSTRUMENTATION
Maintains efficiency, reduces operating cost of treatment
Design and assembly of pneumatic, electric or hydraulic control components for manual or automatic, constant or variable rate plants. Operating consoles and control panels specifically engineered for complete treating plants. BULLETIN 1100

INFILCO
General Offices • Tucson, Arizona • P.O. Box 5033
Field offices throughout the United States and in foreign countries

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INFILCO CAN help you solve any water and brine treatment problem in oil production and refining

From experience, extending over 60 years, INFILCO can give you the best results with lowest *first* cost and *operating* costs.

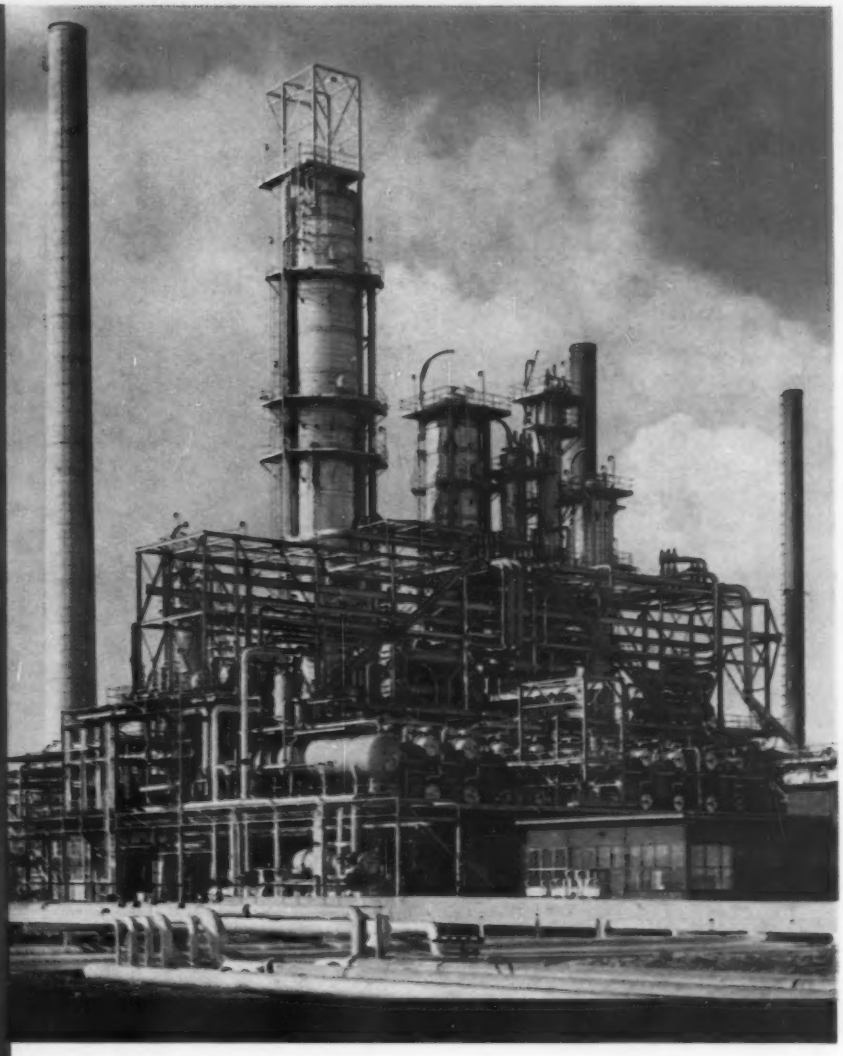
No other line of equipment is so complete—none so advanced in method and design. Above are a few examples.

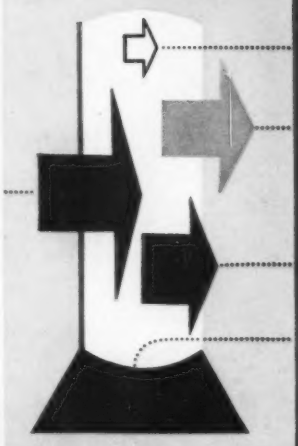
It will pay you to investigate. Inquiries are invited on all matters relating to water or brine treatment. Write today for new condensed catalog, Bulletin 80, for a more complete description of INFILCO products.

THE ONLY COMPANY impartially offering equipment for ALL types of water and waste processing—coagulation, precipitation, sedimentation, flotation, filtration, ion exchange and biological treatment.

At Shell Haven
Stone & Webster
Engineers

Provided High Quality Products, High Efficiency





Stone & Webster adds profits to your project through engineering economies and plant efficiency.

At Shell Haven, England, Stone & Webster Engineering Limited designed and constructed for Shell Refining Company Limited a distillation unit of advanced design to process 80,000 BPSD of Kuwait crude.

The process design represents the joint effort of Stone & Webster and Bataafse Internationale Petroleum Maatschappij and provides for flexibility in the type of feedstocks, close fractionation of products to rigorous specifications and high heat recovery reducing fuel consumption below 1.5 per cent of the charge rate.

A substantially duplicate unit, engineered by Stone & Webster, has been built at Cardon, Venezuela based on this process design.

For information concerning how Stone & Webster can be of service to you on your next engineering project, please write or call our nearest office.

STONE & WEBSTER ENGINEERING CORPORATION

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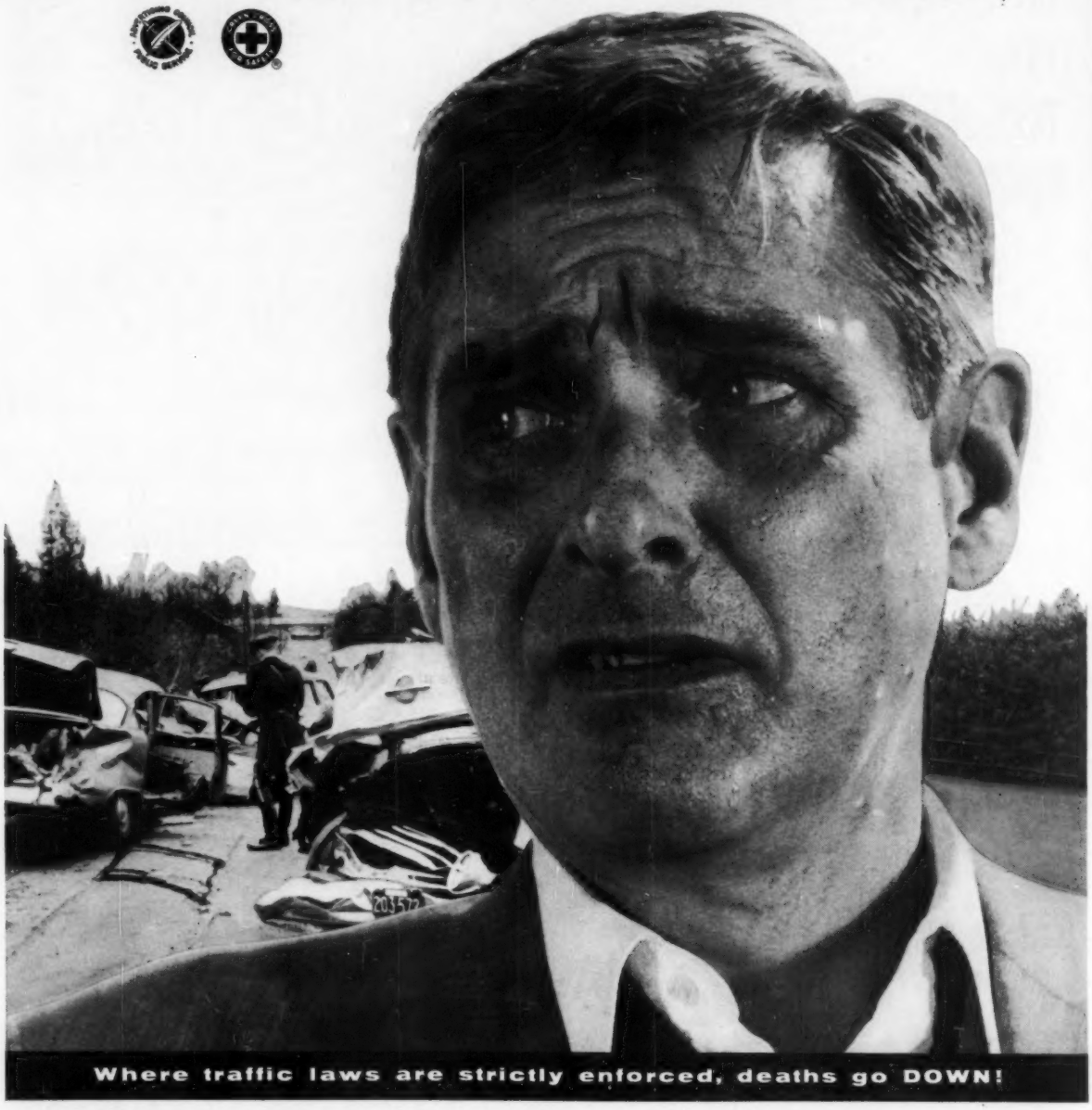
"I wish I could have done something to help . . ."

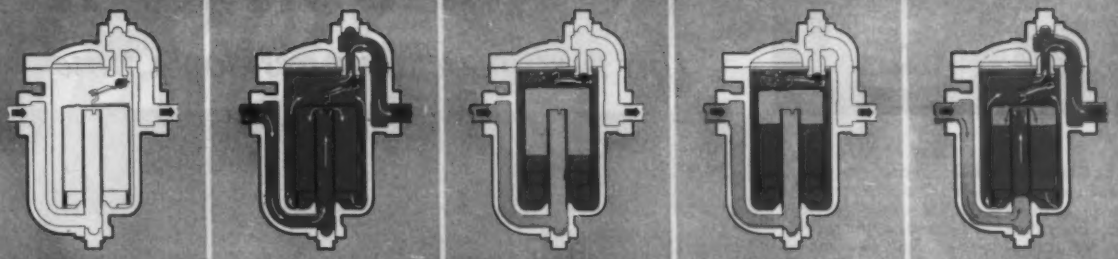
You can do something about traffic accidents! Drive safely yourself—obey the law. Sure. But you can do a lot *more!* Traffic accidents affect *everybody.* Reducing them is a community problem. Its solution calls for systematic, organized effort and cooperation with public officials—for teamwork and leadership. Here is where *you* can help. Join with others who are working actively to promote safe driving and secure strict enforcement of all traffic laws. Make your influence count. *Support your local Safety Council!*



Where traffic laws are strictly enforced, deaths go DOWN!

Published in an effort to save lives, in cooperation with the National Safety Council and The Advertising Council.

This simple trap operating principle provides the efficiency, dependability and freedom from maintenance necessary for the most profitable use of steam



When trap is first installed, the inverted bucket is down and the valve is wide open.

When steam is turned on, condensate (solid color) flows into trap and out through discharge orifice, until —

Steam (light color) reaching the trap floats the inverted bucket and closes the valve.

When more condensate enters the trap, the bucket loses buoyancy and pulls on valve lever.

When weight of bucket times leverage overcomes pressure on valve, bucket sinks and opens trap.

Key: condensate steam steam bubbles air bubbles

ARMSTRONG INVERTED BUCKET STEAM TRAPS

are designed and made to give you these big benefits:

● Amstrong Traps, the first inverted bucket steam traps, now represent the most advanced development of this time-proven principle. They provide all the advantages necessary for efficient, economical condensate drainage from virtually all types of steam using equipment.

1. *No steam loss* – Steam never reaches the orifice even when there is no condensate load.
2. *Automatic air elimination* – Vent in trap bucket passes air and other non-condensibles through to be discharged with condensate.
3. *No cooling leg required* – Condensate is discharged at steam temperature as fast as it reaches the trap because trap operates on difference in density between steam and water not on temperature.
4. *Operates on any back pressure* – Failure of one trap in system will not cause others to open because high back pressure does not affect an Armstrong trap other than to reduce capacity. As long as there is a pressure differential across the orifice the trap will close on steam and open for condensate.
5. *Unaffected by ordinary dirt* — Swirling action of condensate keeps dirt in suspension until discharged with condensate, prevents it from lodging in valve.
6. *Completely dependable* — Proved design plus the use of all stainless steel working parts assure continuity of service and length of service unmatched by any other trap.
7. *Big capacity in a small, economical package* — Armstrong design gives you the highest practical capacity for any given pressure. And remember, Armstrong capacity ratings are based on *hot* condensate at the *working pressure differential* stated, not on theoretical orifice capacities.

Further information on these advantages plus much additional information is given in the 48 page Armstrong Steam Trap Book. Ask your local Armstrong Representative or write direct.

860 Series for low pressure heating service.

800 Series, side inlet, side outlet.

No. 801, side inlet, bottom outlet.

880 Series, integral strainer.

200 Series, bottom inlet, top outlet.

Forged Steel Series for high pressures, high temperatures.

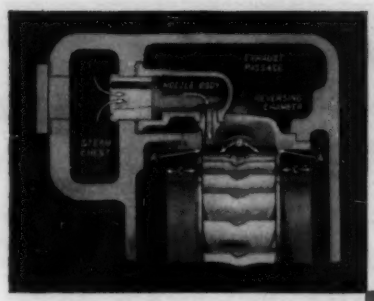
The 48 page Armstrong Steam Trap Book tells how to correctly size, install and maintain steam traps for any pressure, any temperature, any load plus full catalog data on Armstrong Steam Traps. Ask for Catalog K.

ARMSTRONG MACHINE WORKS

8526 Maple Street ● Three Rivers, Michigan

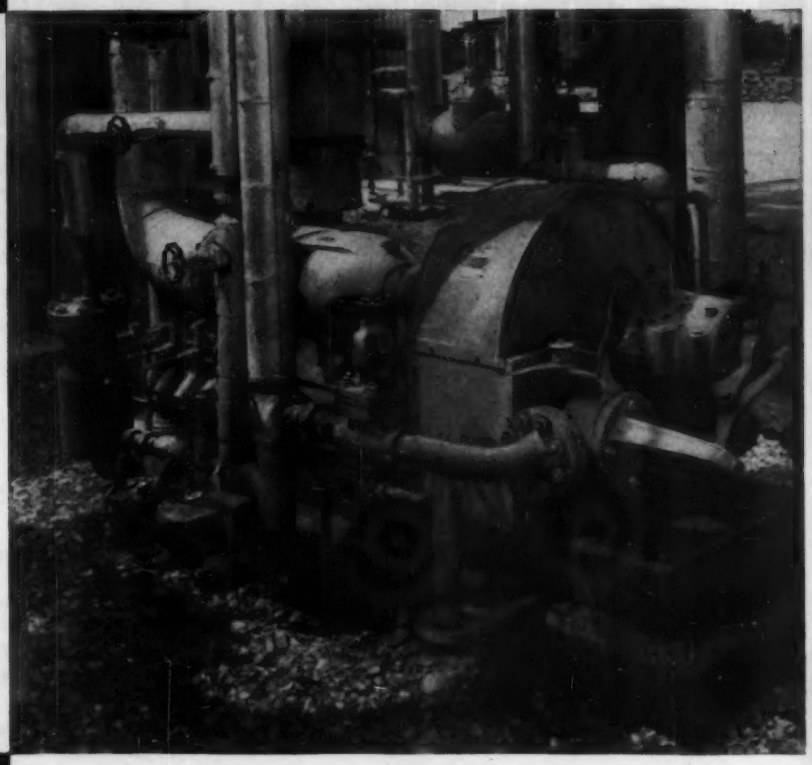
"See Our Catalog in Refinery Catalog"

For more data on advertised products, use Readers' Service Cards, last page.



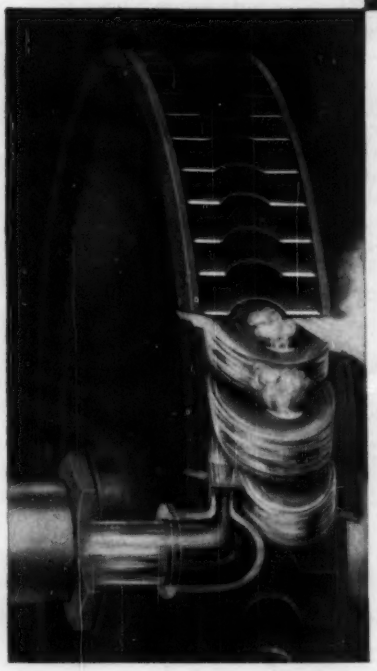
TWO REASONS WHY

this turbine seldom sees down time



1 ***Generous wheel clearances:*** **AA —rim clearance, B—blade clearance, CC —side clearance. Blades can't foul as they are protected by rims. Rubbing at AA will do no damage. Side clearance is so large (about one inch) that end-play from excessive external thrust cannot damage wheel.**

2 ***Blade wear is of little consequence.*** **In a Terry solid-wheel turbine, the steam enters the buckets at right angles to the shaft. As its power-producing action takes place on the curved surfaces at the backs of the buckets, wear does not materially affect horsepower or efficiency.**



To prevent costly shutdowns for repairs, Terry builds bonus reliability into each solid-wheel turbine. Two of the ways in which this is accomplished are shown in the diagrams at the left.

Further details of these simple, fool-proof turbines are illustrated and described in bulletin S-116. If you do not already have a copy of this publication, send for one today. No cost or obligation.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TT-1217

TERRY

new..

Varec" Dynamatic

IGH ACCURACY
T LOW COST

Power Operated

liquid level

TANK GAUGE

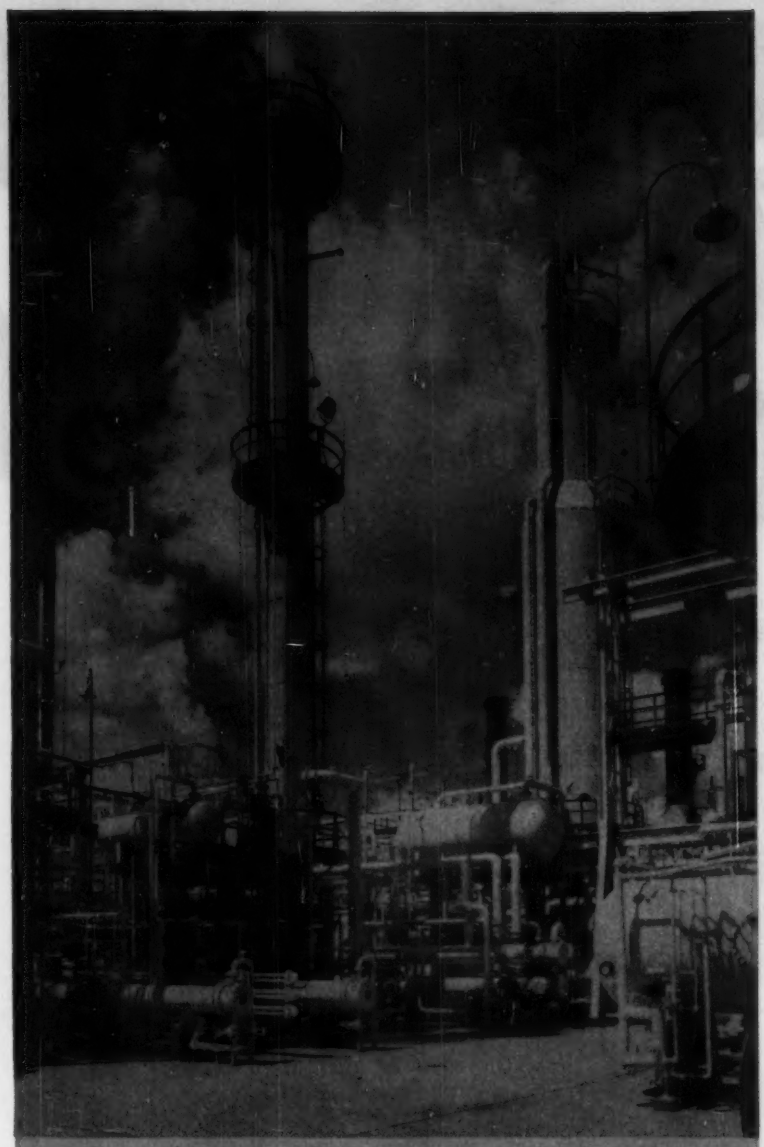
Accurate to better than 1/16".
Readings in feet inches and sixteenths.
Graduations available in metric and decimal.
No floats, counterweights or spring balances.
Large, easy to read numbers on dial and counter.

The *Dynamatic* Power Operated Gauge utilizes a force balance system arranged to detect and display liquid level. The measuring device consists of two elements; a force measuring element and a displacer that is a solid plate of any material suitable to the environmental conditions.

Friction–the specific gravity of the product– the load placed on the gauge head to drive accessory controls and remotes–turbulence–none of these have any adverse effect on the accuracy or reliability of the gauge.

The remarkable low cost and the high level of accuracy and sensitivity have been achieved by Varec's uniqueness of design and not by the sacrifice of quality materials and workmanship. ● *Request Bulletin CP-3705* ●

The Vapor Recovery Systems Company - Compton, Calif.



(Above) This view of Platformer LPG recovery section shows deethanizer (left) and depropanizer tower (center). Third tower (right) is Unifining Unit's stripper column.

New Platforming® unit boosts production of high-octane gasoline nearly 200%

DX Sunray upgrades product quality, boosts motor fuel production capacity with five new UOP process units

by Harry A. Brown
Vice President of Manufacturing
DX Sunray Oil Company,
Tulsa, Oklahoma

In little more than three years after becoming the refining and marketing subsidiary of Sunray Mid-Continent Oil Co., DX Sunray Oil Co. launched a major modernization program.

Harry A. Brown

In early 1959 we placed on stream at our West Tulsa refinery a 20,000 BPSD Unifining* unit, a 12,000 BPSD Platforming unit, a 2,400 BPSD Isomerization Unit and a 2,500 BPSD HF Alkylation unit. At about the same time we added at our Duncan, Oklahoma, refinery a 6,000 BPSD Unifining* unit to an existing layout which already included a 6,000 BPSD Platforming® unit, a 22,000 BPSD Fluid Catalytic Cracking unit, a 3,500 BPSD HF Alkylation unit and a 750 BPSD Catalytic Condensation unit. Installed at a cost of $12 million, and designed and engineered by Universal Oil Products Company, our new units are the most modern available and were installed to carry out our avowed objective of marketing high-quality products.

Triples high-octane output

The four UOP units provide more high-octane gasoline than the Tulsa refinery previously manufactured. The new Platformer almost triples the output of high octane gasoline there, and addition of the new HF Alkylation unit more than doubles DX Sunray's potential for producing 105-octane gasoline.

*Trademark

Being charged to the new Unifining unit is a blend of straight-run and coker naphthas for preparation as feed stock to two Platformers. These include a 7,500 BPSD reforming unit that was converted to UOP Platforming in June of 1956 and the new 12,000 BPSD unit completed this year. At relatively low cost, Unifining desulfurizes and purifies the Platforming feed stock and transforms olefins into paraffins. Combined operation with Platforming provides a most economical source for the hydrogen required in Unifining.

LPG unit recovers butane, propane

At the new Platforming unit, the Unifined, depentanized C_6-plus naphtha, or feed stock, is heated and contacted with a specially prepared platinum-containing catalyst under operating conditions to produce a C_5-plus gasoline with a leaded octane number as high as 99, if required. A rerun tower is provided for preparation of selected blending stocks. In conjunction with the Platformer there is an LPG unit designed to recover 92% butane and 60% propane.

In conjunction with the decision to modernize the Tulsa refinery, we gave careful consideration to future demands for higher-octane gasoline. Expanded facilities for alkylation, to produce motor alkylate as a blending component, were chosen since sufficient quantities of butane available in our refinery streams could be isomerized and, as isobutane, utilized as one of the feed stocks for HF Alkylation. Universal engineers, therefore, designed a 2,400 BPSD Butane Isomerization unit to service the HF Alkylation facility. The two processes are controlled and operated as a single unit.

Could produce 105-plus leaded octane

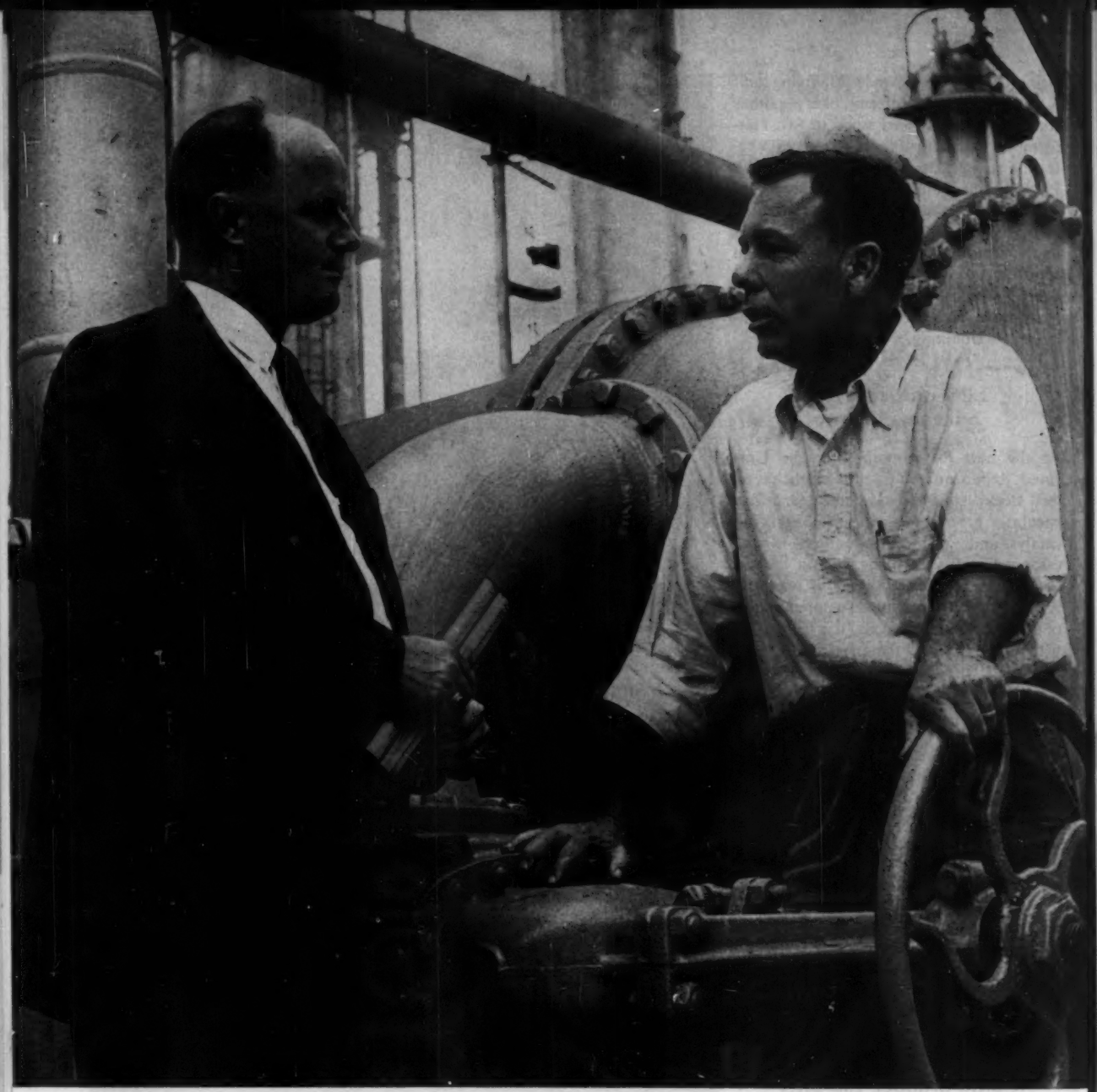
The HF Alkylation unit product is 2,500 BPSD of 105-octane gasoline blending stock. Actually, the unit would permit the Tulsa plant to turn out gasoline exceeding the 105 octane number (leaded) if market conditions should so dictate. However, DX Sunray has no immediate plans for producing motor fuels in such super ranges. If and when the need for higher-octane gasoline arises, we're ready for several years to come. Meanwhile, much of this high-octane alkylate is used to manufacture aviation gasoline. The remainder is blended with other refinery stock to produce a premium gasoline which is equal or superior in quality to any in the DX marketing area.

Combination HF Alkylation— Butane Isomerization unit assures potential production of super-octane gasoline

View of DX Sunray's Isomerization unit showing three reactors at left. Second tallest tower (center) is the debutanizer column. Deisobutanizer (right) is the highest refinery tower in Oklahoma.

UOP® UNIVERSAL OIL PRODUCTS COMPANY
30 Algonquin Road, Des Plaines, Illinois, U.S.A.
More Than Forty Years Of Leadership In Petroleum Refining Technology

For more data on advertised products, use Readers' Service Cards, last page.



Photographed at Gulf Refinery, Philadelphia, Pa.

THE GOLDEN RULE THAT PRODUCES RESULTS...

Our golden rule is teamwork between refiners and Cyanamid. As a result of this teamwork, Cyanamid produced the first fully regenerative platinum reforming catalyst and helped develop the first micro-spheroidal synthetic fluid cracking catalyst. Continued co-operation between refiners and Cyanamid is sure to produce further advances in catalytic refining techniques.

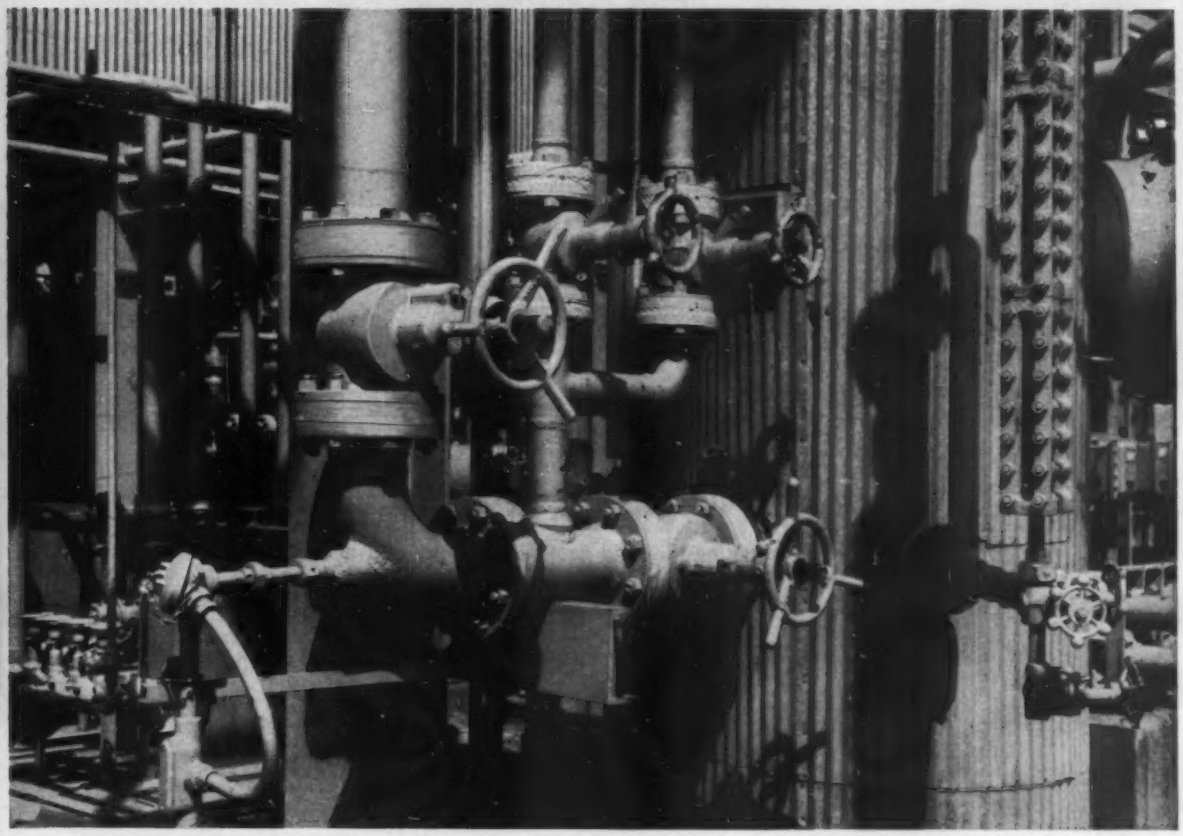
Symbolizing this co-operation is Cyanamid's salesman–the man with the golden rule. You can depend on him at all times for help in meeting the operating problems caused by demands for ever-improved fuels. His personal knowledge is backed by the research and production facilities of one of the world's leading producers of catalysts. Call him anytime he can be of help to you . . .

Basic in catalyst chemistry CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, N.Y. 20, N.Y.

STOP PRODUCT CONTAMINATION BEFORE IT BEGINS BY USING ORBIT FORGED STEEL VALVES

Because of the non-lubricated positive closure seating principle used in the Orbit Valve, costly maintenance and the possibility of fluid contamination carry-over from valve lubricants which lower catalyst efficiency has been eliminated. Lubricant is not required for any part of the valve's mechanism that comes in contact with fluid being handled in cavity of valve.



Service shown here: Hydrogen Plant — Makeup Unit to Dehydrator.

Literature: Write Department B for Catalog 58-B and Service Manual No. 58.

Source: Available through your favorite industrial supply house.

ORBIT VALVES®

ORBIT VALVE COMPANY

P. O. BOX 699 • TULSA, OKLAHOMA • Phone LUther 4-4761 • TWX TU 925

For more data on advertised products, use Readers' Service Cards, last page.

Fluid catalytic cracking unit, Toledo (Ohio) refinery, Standard Oil of Ohio

Refractory insulating concrete stops corrosion in this new FCC

In constructing the fluid catalytic cracking unit at Sohio's new Toledo refinery, corrosion resistance, abrasion resistance and insulation were built in right from the start. Refractory insulating concrete, bonded with LUMNITE calcium-aluminate cement, was used to line the regenerator, cyclones, stripper, catalyst and reactor transfer lines. Now on stream, these industrial concrete linings will resist severe erosion and abrasion caused by catalyst fines... resist attack by acid condensate... and provide insulation at high temperatures.

Installation of monolithic concrete linings is fast, easy, economical — whether cast in place, gunited or plastered. Concrete reaches service strength in 24 hours.

For added convenience, castables bonded with LUMNITE cement are available from leading manufacturers of refractories. These are packaged mixtures, ready for use with just the addition of water. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N.Y.

"USS," "Atlas" and "Lumnite" are registered trademarks L-195

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Layne

the only complete water service organization

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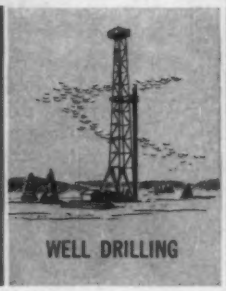
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WELL CASING AND SCREEN

PUMP DESIGN, MANUFACTURE AND INSTALLATION

Complete service means undivided responsibility

CONSTRUCTION OF WATER SYSTEMS

COMPLETE RESEARCH STAFF AND FACILITIES

MAINTENANCE AND SERVICE

CHEMICAL TREATMENT OF WATER WELLS

WATER TREATMENT

In an age of specialization there is a definite advantage in doing business with a company offering a COMPLETE SERVICE . . . providing *all* the services allied to the field of water.

Only Layne with its network of Associate Companies, and over 75 years of experience, all backed by Layne Research can offer its customers a complete water service which makes Layne unique in the industry.

World's Largest Layne *Water Developers*

LAYNE & BOWLER, INC., MEMPHIS

Offices and Factory • Memphis 8, Tenn.

LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD

New... from MARSH!

MARSH
Master-mite
SOLENOID VALVES

Small solenoid valves that Fill a BIG order

Yes, a series of small, direct acting solenoid valves that fulfill today's critical requirements for rugged, positive-acting tight-seating valves in types, patterns, orifice sizes and electrical ratings for use on a particularly wide variety of media including air, water, petroleum products, coolant, oxygen, hydrogen and acetylene.

They are new only in the production sense. Actually this announcement was preceded by long development and research which drew on more than 90 years of experience in instrument and valve making.

The net result is a valve that combines instrument-precision with the ruggedness that distinguishes all Marsh Valve Specialties!

Despite their small size, "Master-mite" Solenoid Valves are more rugged because the "beef" is where it counts—in the valve body. The generous, moisture-resistant coils do not overheat. Entire assembly is leak-tight at pressures up to 540 psi. Operation is positive . . . yet quiet. Valves can be cleaned without breaking connections . . . can be used in any position.

Bodies are available in either brass bar stock or 18-8 stainless steel. All parts in contact with media are stainless steel. Down to the last detail, "Master-mite" solenoid valves are designed and built to stand up and work right under the toughest conditions including vibration. They are Underwriters' approved for use on oxygen and hydrogen and as safety valves.

Read the accompanying specifications. Note the wide range of selection. Ask for bulletin containing all details.

Note these specifications

★ **Types:**	Direct acting conduit type and grommet type. Four patterns of each size and type: globe, bottom outlet, angle left, and angle right.
★ **Sizes:**	⅛" and ¼" NPT.
★ **Pressures:**	From vacuum to 540 psi. maximum.
★ **Orifice sizes:**	Ten sizes: 3/64", 1/16", 5/64", 3/32", 7/64", 1/8", 9/64", 5/32", 3/16", 1/4".
★ **Voltages:**	Standard with 115 volts 50/60 cycle AC coils, but also available in 12, 24, 208, 230 and 460V, 50/60 cycle coils.
★ **Leads:**	Standard with 18", but other lengths available; also full range of connectors.
★ **Body:**	Brass bar stock or 18-8 stainless steel.
★ **Moving parts:**	All stainless steel.
★ **Seat disc:**	Synthetic rubber.
★ **Approved by Underwriters' Laboratories as a safety valve.**	

New bulletin tells the whole story

Shows all types, patterns, sizes, coils, options, etc., and contains highly useful flow curves.

MARSH INSTRUMENT COMPANY
Dept. R, Skokie, Illinois
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

only **U. S. MOTORS**

insulates all windings with asbestos!

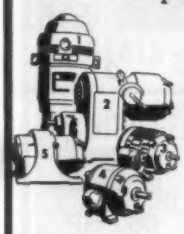
U. S. Uniclosed Dripproof Motors— 1 to 250 H.P.

U. S. Totally-Enclosed and Explosion-Proof Motors— 1 to 150 H.P.

your best protection against motor burn-out and production shut-downs

Only U.S. offers this protection! ALL windings insulated with asbestos—nature's million-year-old insulating material that *cannot carbonize!* Many motor makers use varnished paper, cloth, oiled linen, pressboard, fish-board—even insulating varnish alone. All these will carbonize... not one is fire-proof!

Only the original, patented U.S. Asbestic Process—gives you: 1—*heat resistance*... can't carbonize, 2—*heat conductance* better than any cellulose material, 3—*moisture resistance*... due to exceptional impregnation and coating of all motor windings. Protect against costly production stoppages due to motor burn-out! Specify: "U.S. Motors"!



U.S. ELECTRICAL MOTORS INC.

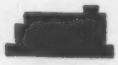
BOX 2058, LOS ANGELES 54, CALIFORNIA
OR MILFORD, CONNECTICUT

U.S. MAJOR MOTOR LINES INCLUDE:
1. Vertical Solid & Holloshaft, 2. Varidrive, 3. Totally-Enclosed, 4. Uniclosed, 5. Syncrogear. Also, many other special motors.

FREE COLOR-ILLUSTRATED BROCHURES...
For specific data on asbestos protection, write for General and Type H Uniclosed Bulletins.

THE UNVARNISHED FACTS

about engine compressors in the 375 to 950 hp range

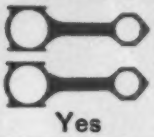
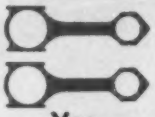
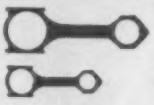
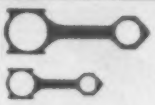
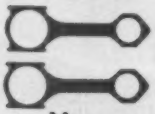
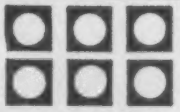
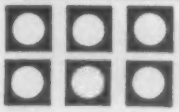
FEATURE	WORTHINGTON SLHC	MFR. A	MFR. B	MFR. C
DESIGNED FOR TURBOCHARGING	Yes	No	No	No
SELF-SUSTAINED TURBOCHARGING	YES	NO	NO	NO
FUEL CONSUMPTION	7,000 BTU/BHP HR	9,000 BTU's	8,600 BTU's	8,500 BTU's
CYCLE	4	2	2	4
CYLINDER ARRANGEMENT	Inline	Inline	Vee	Vee
RPM	450	600	450	400
YEAR ENGINE WAS DESIGNED	1955	Before 1950	Before 1940	Before 1940
NUMBER OF DESIGNS TO COVER RANGE	1	2	2	2
LARGEST UNIT FOR SKID MOUNTING	950 HP	 660 HP	1100 HP	660 HP

For more data on advertised products, use Readers' Service Cards, last page.

On these two pages you'll find a comparison of all the significant facts about gas engine compressors in the 375 to 950 horsepower range. We think you'll have to agree that Worthington's SLHC unit is the outstanding performer in its size range. Not only does it have 18% better fuel economy than the next nearest engine, but it also features self-sustained turbocharging, removable cylinder liners with cast-in water jacket, interchangeable power and compressor rods, and many other important engineering advances.

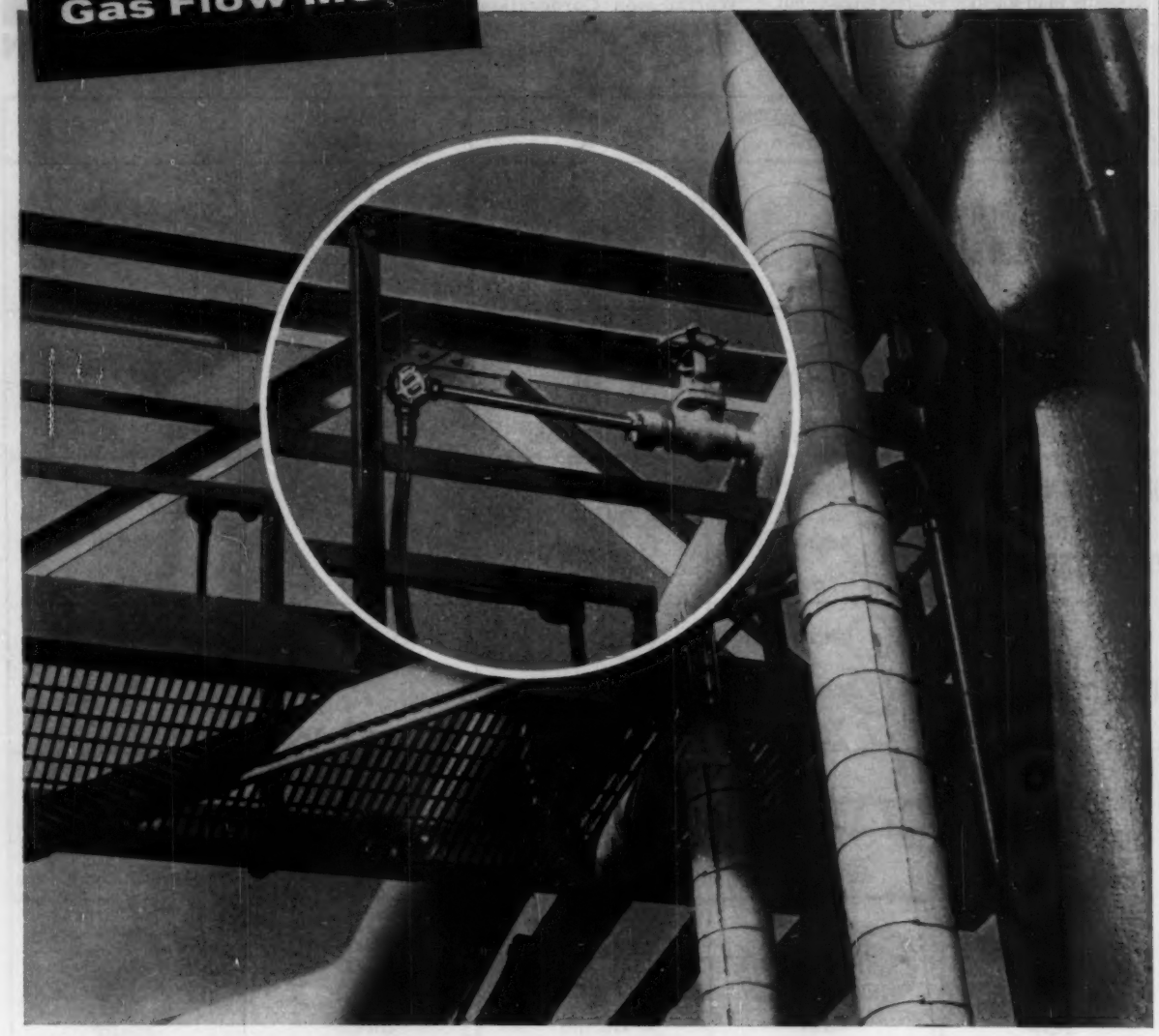
For complete details on the new SLHC engine compressor get in touch with your nearest Worthington district office. Or write to Worthington Corporation, Section 43-4, Harrison, N. J. In Canada: Worthington (Canada) Ltd., Brantfold, Ont.

WORTHINGTON

FEATURE	WORTHINGTON SLHC	MFR. A	MFR. B	MFR. C
MOUNT CYLINDERS ON BOTH SIDES	Yes	No	No	No
CYLINDER LINERS	Removable	Removable	NONE	NONE
INTERCHANGEABLE POWER AND COMPRESSOR RODS	 Yes	 Yes	 No	 No
SIDE BY SIDE CONNECTING RODS	Yes	 Yes	No	No
FRAME CONSTRUCTION	En-bloc	En-bloc	 Separate Cylinders	 Separate Cylinders
IGNITION	Twin	Single	Single	Single
RUNNING GEAR LUBRICATION	MANIFOLD CAST IN BASE	SEPARATE PIPE MANIFOLD	SEPARATE PIPE MANIFOLD	SEPARATE PIPE MANIFOLD
GASKET-FREE CYLINDER HEAD SEATS	YES	NO	NO	NO
RUNNING GEAR EASILY ACCESSIBLE	YES	NO	NO	NO

For more data on advertised products, use Readers' Service Cards, last page.

"Anemotherm" Gas Flow Meter cuts flare stack losses



Are thousands of dollars going up your flare stack? You can substantially reduce these flaring losses with the "Anemotherm" *Probe-Type* Gas Flow Meter. This electronic, stainless steel instrument accurately measures the gas flow in the flare stack and the lines leading into it from various units. By determining flow rates and points of loss, refineries report savings of thousands of dollars per day.

Investigate the application of the "Anemotherm" Gas Flow Meter's wide range measurement, response to low velocities and available control functions in the following fields:

- *controlling atmospheric pollution*
- *increasing combustion efficiency in boilers, furnaces and heat treating equipment*
- *measuring the flow of air in catalytic cracking units*
- *metering the rate of flow in gas transmission lines.*

Put the money-saving accuracy and efficiency of the "Anemotherm" Gas Flow Meter to work for you. *Send for 8-page Technical Bulletin 5100 giving complete engineering data.*

ANEMOSTAT®

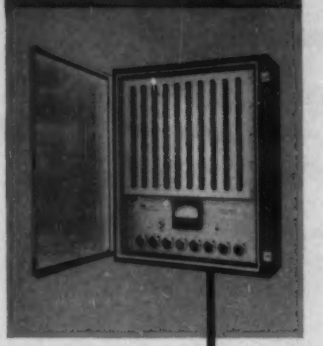
ANEMOSTAT CORPORATION OF AMERICA

10 East 39th Street, New York 16, N. Y.

Representatives in Principal Cities

AC 1373

CM-2



PROCESS OPTIMATION

OPTIMATION IS THE NEW WORD AT SIE AND DRESSER

The word at SIE is "OPTIMATION" (optimum efficiency or yield through automation). SIE solid state instrumentation gives you —

- AUTOMATIC SCANNING AND MONITORING
- PROCESS DYNAMICS RECORDING
- DATA REDUCTION
- COMPUTER CONTROL

The SIE Control Division will study your process with advanced techniques to determine optimum controls. This is Optimation — Optimation that can increase your profits.

Write Rex Grey for further details

Control System Specialists devoted to the oil industry

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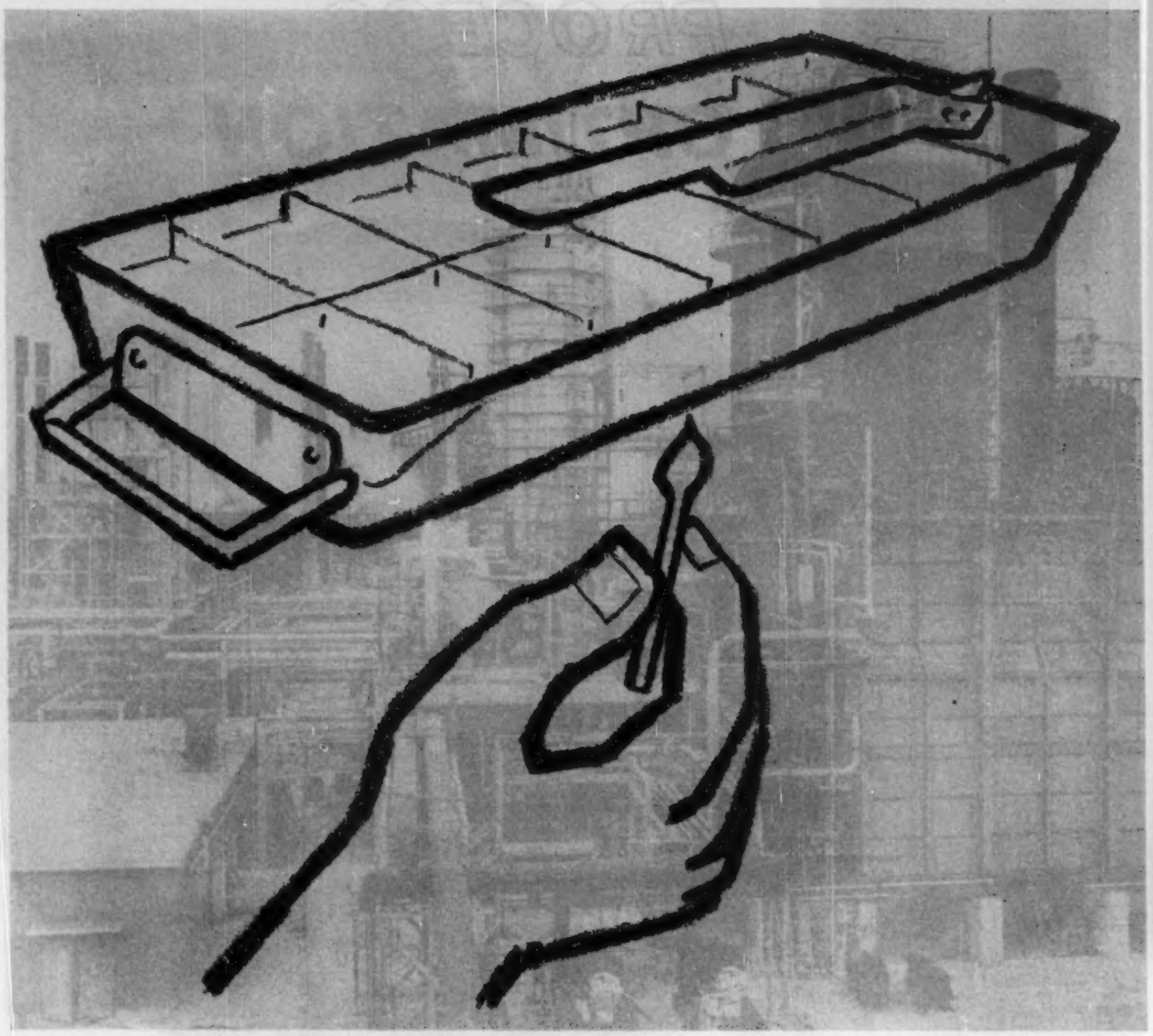

RESISTS THERMAL SHOCK!

. . . another virtue of ductile iron* Stanco Valves

Numerous tests show that ductile iron, with all its other advantages, also possesses resistance to thermal shock equal to that of cast carbon steel.

Its other advantages include a metallographic structure which resists leakage or seepage by liquids or gases, so that Stanco valves made of ductile iron are *pressure tight*. Ductile iron has elevated temperature strength comparable to cast steels, and corrosion resistance equal to cast iron.

Get the complete story on the advantages that Stanco valves of ductile iron offer petroleum engineers — and then check up on the savings to be made through their use!

From pattern making to testing, Stanco can help you with your valve problems, whether you need a valve from Stanco's broad line of production valves, or a special design to your specific requirements. Try us, and see!

* Trade Mark of the International Nickel Co.

STANDARD BRASS & MANUFACTURING CO.

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where trouble-free performance is a matter of national security

each of newest nuclear subs will take aboard **MORE THAN 4 MILES** of Scovill cupro-nickel, 30% heat exchanger tube

SCOVILL®

We're proud to be making this important contribution to the long-service dependability of these nuclear-powered submarines.

Like all other components of their nuclear-powered propulsion machinery and equipment, the Foster Wheeler main condensers, shown above being tubed with Scovill Cupro-Nickel, 30% Heat Exchanger Tube, have passed the most exhaustive performance tests it has been possible to devise. The same tube specification is also being installed in the ejector condensers. All of the tube is electronically tested on new equipment at the Scovill Tube Mills before delivery.

Scovill Cupro-Nickel, 30% Heat Exchanger Tube has a long record of trouble-free service on U. S. Naval vessels and those of many other nations. It is a first choice of design and operating engineers where salt water or corrosion conditions are severe, particularly at elevated temperatures and when the circulating media travel at high velocities. The corrosion resistance is excellent; strength of the alloy remains constant over a wide temperature range.

Why not discuss your own heat exchanger tube conditions and problems with Scovill Technical Service . . . considered by many the most experienced in the field.

HEAT EXCHANGER TUBE

for Applications from Marine to Petrochemical, from Compressor Intercoolers to "Cat-Cracker" Exchangers, in these popular Alloys . . . Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Red Brass, 85% • Deoxidized Copper • Arsenical Copper • Cupro-Nickel, 10%-20%-30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube.

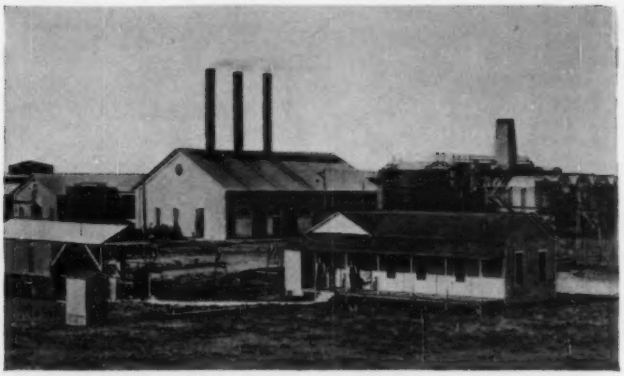
SCOVILL MANUFACTURING COMPANY, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone PLaza 4-1171.

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

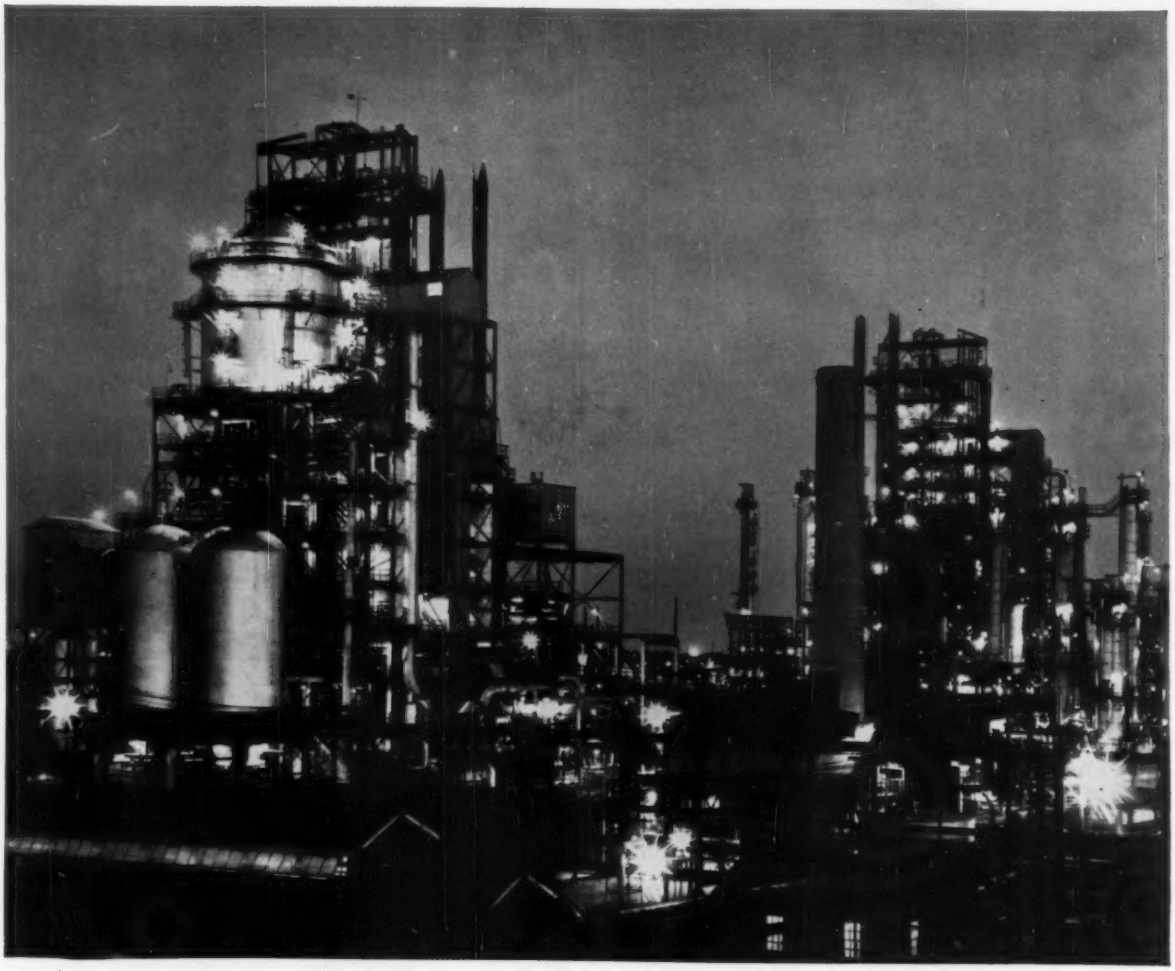
185

NEWS ON TEXACO PROGRESS

Two views of progress . . . 57 years apart



YESTERDAY. Texaco's first refinery at Port Arthur came into being in 1902 to turn the black crude oil — newly discovered in quantity — into useful products for mankind. Produced in simple stills, the first products were kerosine, naphtha, asphalt and primitive lubricants.



TODAY. At Port Arthur, and at 11 other major Texaco refineries in the United States, ultra-modern chemical wizardry uses many methods to produce constantly improved gasolines, perfected lubricants, and a myriad of other petroleum products. Because these products are so vastly improved, you can drive a more powerful car — jet planes can fly faster and farther — industry can operate more efficiently. And because it has constantly planned ahead, Texaco's growth has been continuous.

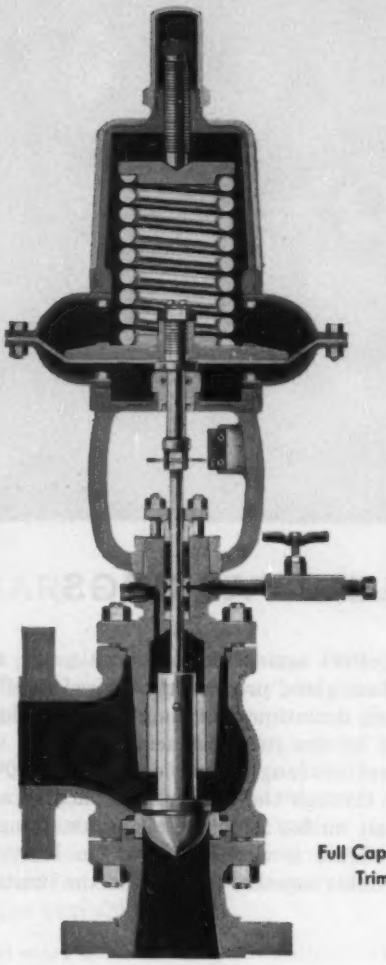
TEXACO

. . . CONSTANT PROGRESS
IN OIL'S FIRST CENTURY

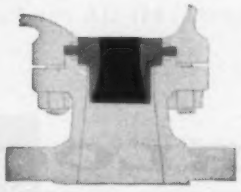
For more data on advertised products, use Readers' Service Cards, last page.

A new and better ANGLE CONTROL VALVE

. . . for easier maintenance and dependable performance



Full Capacity Trim



40% Capacity Trim

This is a *new* control valve from Honeywell . . . the Type 10 angle valve with body ratings to 600 lbs. Makes piping easier when a valve is needed at a turn. Reduces turbulence and cavitation through an improved venturi effect, when flow is directed to close the valve. And because of the venturi effect, this valve is excellent for slurries, viscous or flashing flow mediums.

CHECK THESE ALL-IN-ONE-VALVE FEATURES:

- **clamped-in seat ring . . .**
  fixed in place . . . gasketed on both sides. Flanged tailpiece permits fast removal, assures good alignment.
- **bolted bonnet . . .**
  allows plug and stem replacement without removing body.
- **flushing connection . . .**
  prevents clogging of guide bushing when slurries are flowing.
- **trim selection . . .**
  full or 40% capacity trim . . . expandable outlets for flashing service.

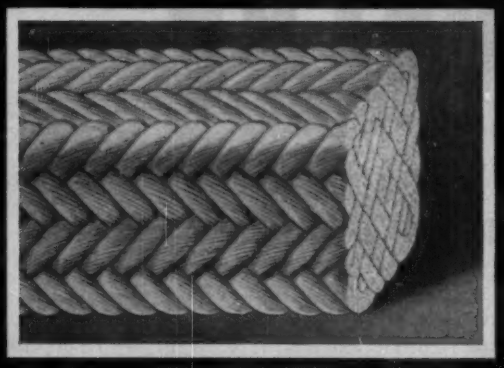
For further information, contact your local Honeywell field engineer . . . he's as near as your phone. Write for Catalog C800-1. MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.

Honeywell

First in Control

For more data on advertised products, use Readers' Service Cards, last page.

How Processors Seal Corrosives . .



GARLOCK LATTICE-BRAID* TEFLON† PACKINGS

On pumps and engines, LATTICE-BRAID TEFLON is just about perfect against petrochemicals, oils, and gases of all kinds. It is strong, long-lasting, chemically-inert. Less gland pressure is required to effect an adequate seal, resulting in longer sleeve and packing life, less downtime and maintenance. Add to these features the advantage of Teflon: completely unaffected by the strongest acids, solvents, and alkalies; extremely low co-efficient of friction; withstands temperatures ranging from −120° to +500° F. In LATTICE-BRAID construction each strand passes diagonally through the body of the packing at a 45° angle. This through-and-through braiding makes a completely unified structure of greater strength. Ordinary braided packings become worthless once the outer braid is worn through. On LATTICE-BRAID, there is no single outer braid; the braiding, therefore, holds together far beyond the limits of other packings, resulting in longer life.

*Registered Trademark
†DuPont Trademark for TFE Fluorocarbon Resin

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals,
Molded and Extruded Rubber, Plastic Products

... Lower Maintenance Costs

GARLOCK TEFLON-JACKETED GASKETS

For piping, flanges, and fittings, TEFLON-jacketed gaskets give you the advantage of using TEFLON without sacrificing resiliency and deformability . . . particularly important on your glass-lined process equipment, light metal flanges, and glass pipe flanges and fittings.

Garlock offers TEFLON-jacketed gaskets in four basic designs—slit envelope, milled envelope, formed shield, and double jacket. Once you've selected the design best suited for your application, choice of filler material and thickness of the gasket becomes extremely important. Here, too, Garlock has a material for every operating condition—for high pressures, a corrugated stainless steel filler is suggested. Where the application is for glass-lined steel connections with low bolt loads, a rubber filler should be sandwiched between woven asbestos cloth. Cork, rubber, asbestos are just a few of the filler-types available.

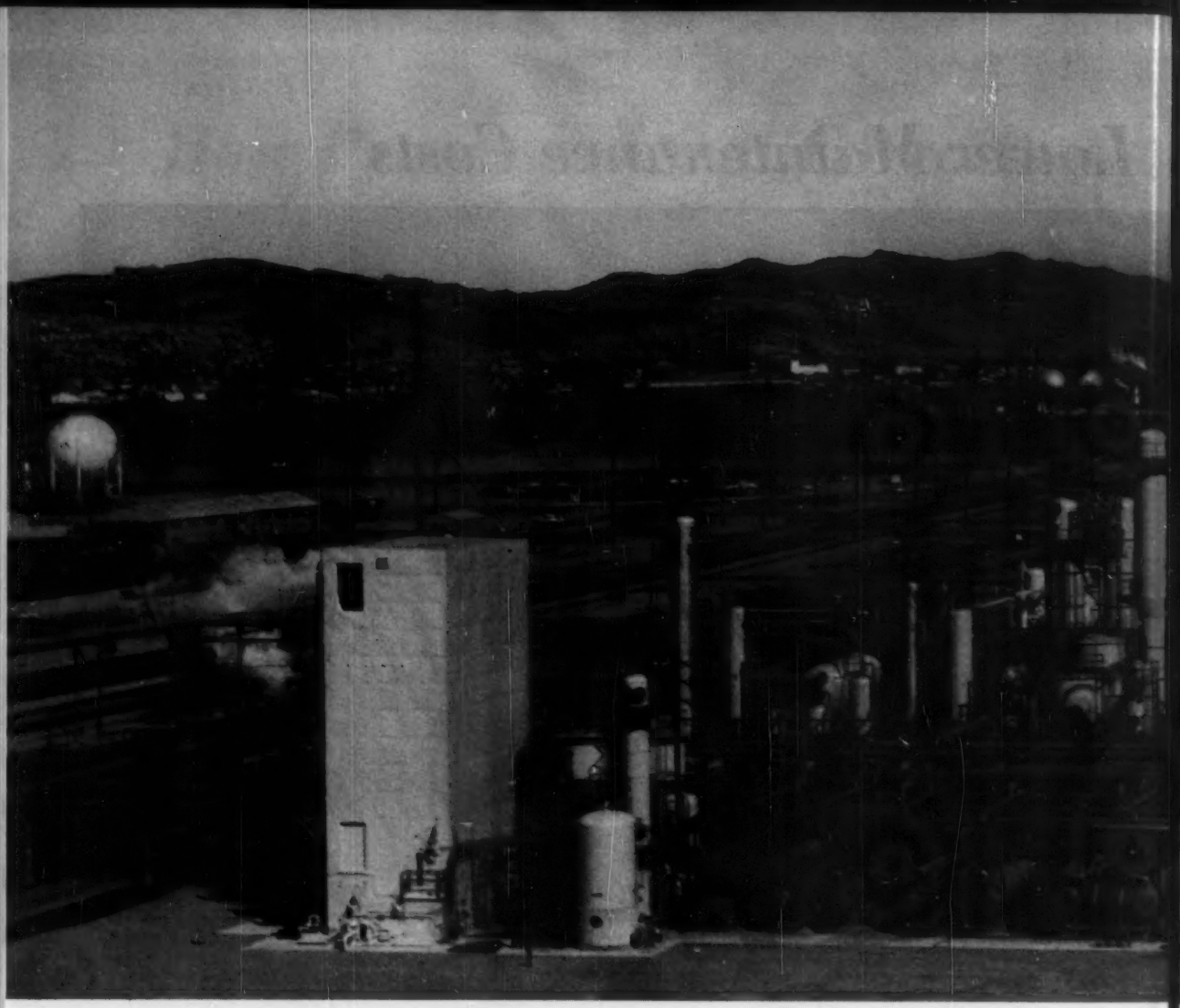
Get more details on LATTICE-BRAID TEFLON Packings and TEFLON-Jacketed Gaskets from your local Garlock representative. He can recommend from the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Call him, or write for Catalog AD-131 (LATTICE-BRAID Packings) and AD-154 (TEFLON Gasketing).

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

Canadian Division: The Garlock Packing Co. of Canada Ltd.
Plastic Division: United States Gasket Company

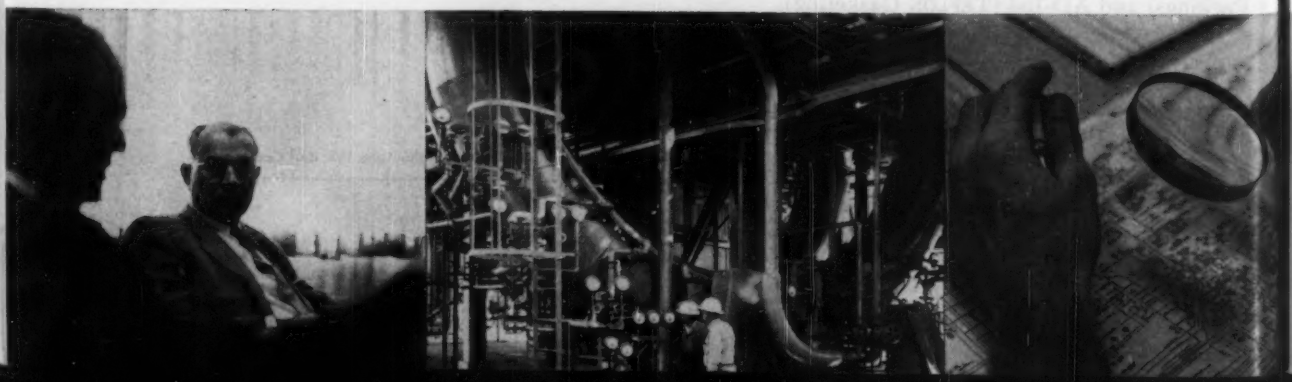
For more data on advertised products, use Readers' Service Cards, last page.

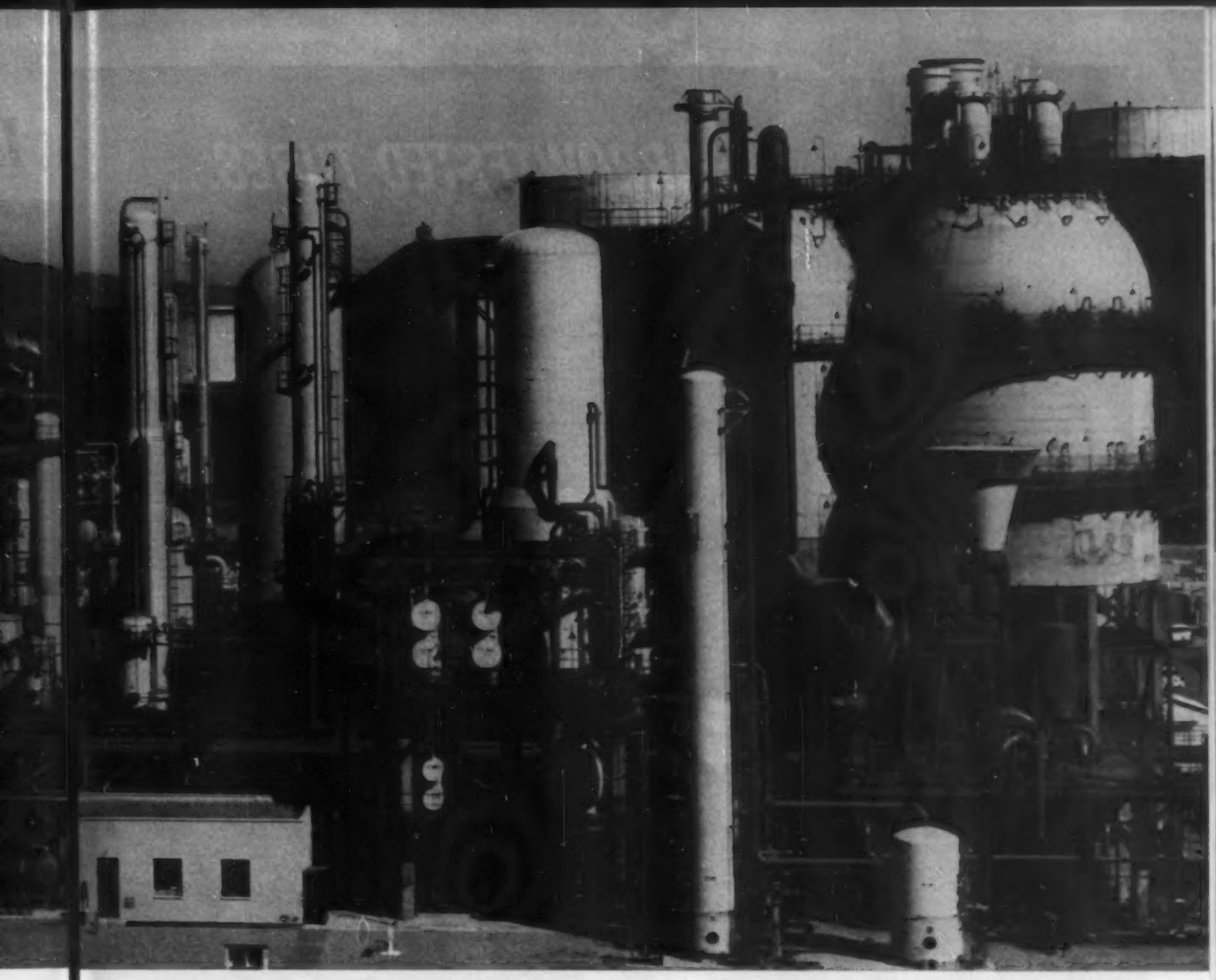


What's new in cat crackers?

The art of catalytic cracking has reached a highly advanced state. The improvements and refinements that now take place as new crackers are built seem minor indeed when one recalls the series of spectacular breakthroughs that followed one after another during cat-cracking's first eventful decade.

Yet there is drama even today. Sometimes it takes the form of a successful race against time. A record of sorts was set recently when the unit above was completed by Fluor for Standard Oil Company of California at its Richmond refinery on San Francisco Bay. It is an Esso Model IV





Fluid Catalytic Cracker with a capacity of 55,000 barrels per day, and it was delivered to the customer in time for the summer marketing season—two weeks less than one year after work began.

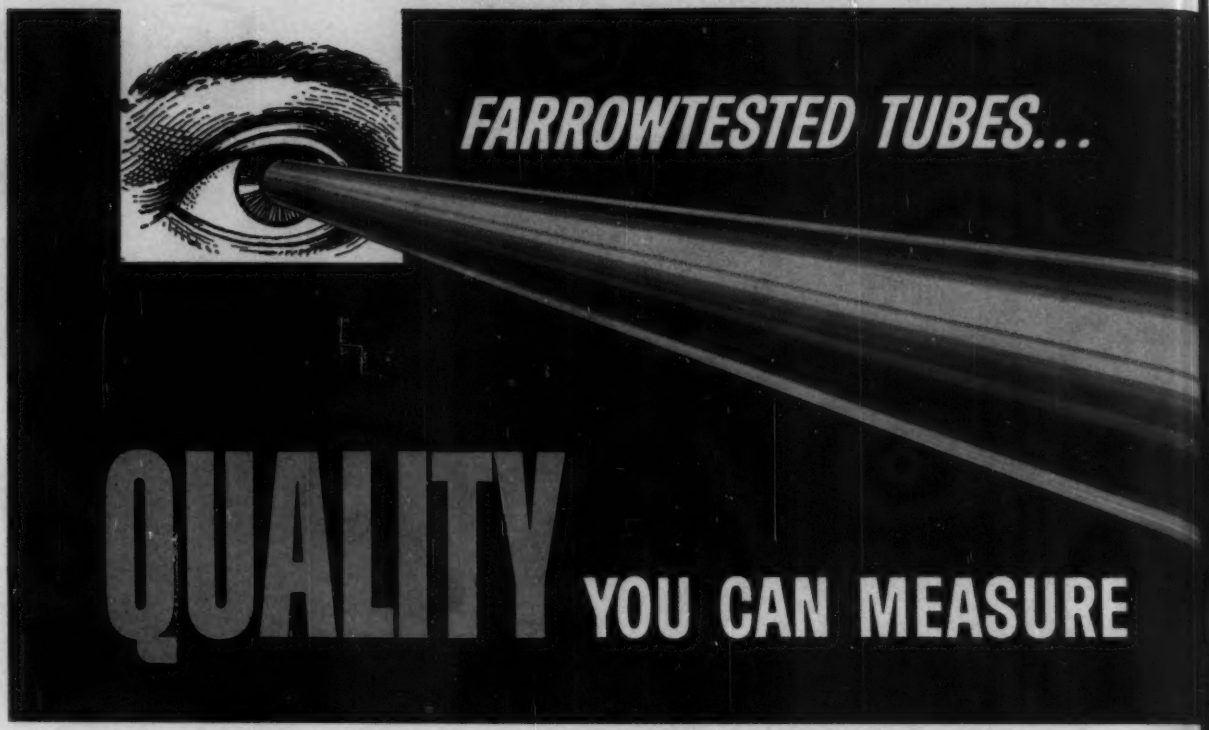
It is one of the two largest Model IV's in existence. The other, of the same capacity, was built by Fluor in 1954 for Standard at El Segundo. The Richmond and El Segundo units are almost identical except for auxiliaries (Richmond has a fired heater, a CO boiler and water-treating facilities). A few minor design and material changes, based on experience at El Segundo, were incorporated into the new unit.

The job was begun on June 2, 1958, and completed May 15, 1959. Credit for the fast completion is due to many factors—organization, planning, fine co-operation from customer and suppliers, and good luck. But perhaps the most important element of all was Fluor's broad experience in the design, engineering and construction of cat crackers—nearly thirty of them since 1940.

A Fluor brochure, "FCC at Richmond," describes this interesting unit. Write to Dept. 90, The Fluor Corporation, Ltd., 2500 South Atlantic Boulevard, Los Angeles 22, California.

When you consider expansion...
the most important investment you can make
is in the creative ability of men

FLUOR
Engineers & Constructors



Republic ELECTRUNITE

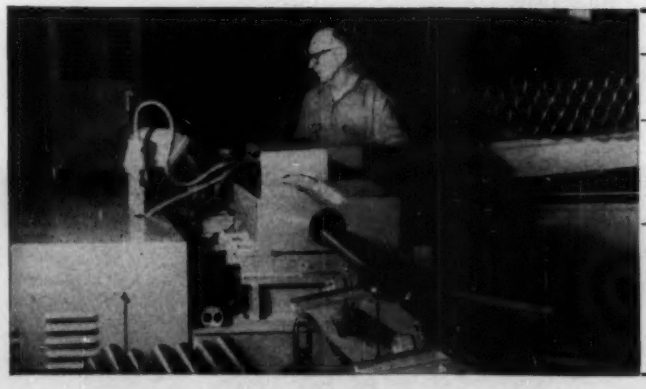
HEAT EXCHANGER TUBING... CARBON AND STAINLESS STEELS

Specify FARROWTESTED Republic ELECTRUNITE® Heat Exchanger Tubing and get predictable, dependable service every time!

FARROWTESTED tubes must pass the most searching test of all, a non-destructive eddy-current test that probes for and detects injurious defects. The "magic eye" of FARROWTEST® looks deep within the tube wall, is calibrated to reject tube with defects as shown in table below. Defects that pass internal fluid or gas pressure tests cannot pass FARROWTEST! This is an exclusive test with Republic.

Quality you can measure! FARROWTEST is offered as an alternative to other less positive tests at no increase in cost. Carbon steels produced to ASTM specification A-214; stainless steels to A-249. Both specifications include eddy-current requirements.

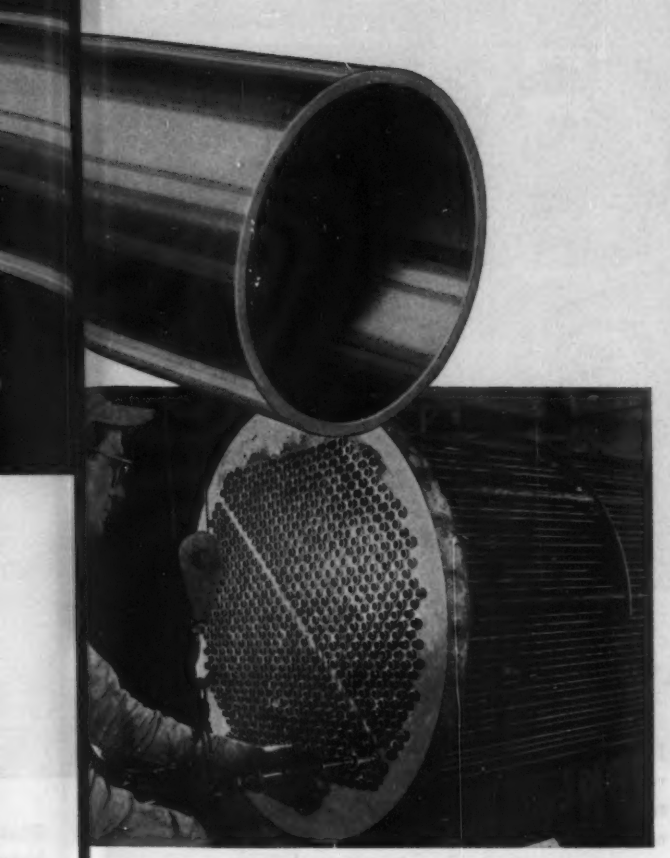
As a tube buyer and user, you owe it to yourself and your company to get ELECTRUNITE and FARROWTEST facts firsthand. Call your Republic representative. Or, use coupon and write direct.



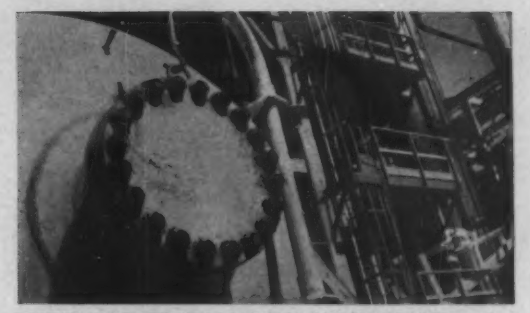
FARROWTEST REJECT TABLE

Wall Thickness (B.W. Gage)	Minor dimension of the defect (Length or Depth)	Defective Area (Length, Depth Plane)
20	.006"	.0025 sq. inches
18	.006"	.003 sq. inches
16	12½% of wall	.003 sq. inches
14 and 13	12½% of wall	.004 sq. inches
12 and heavier	12½% of wall	.005 sq. inches

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.



REPUBLIC ELECTRUNITE STAINLESS STEEL HEAT EXCHANGER TUBING rolls in easy. You get a good tight seal every time. That's why more and more refineries and processing plants are using ELECTRUNITE for original equipment and for retubing operations. Write today.



REPUBLIC ALLOY STEEL STUDS AND HIGH CARBON HEX NUTS provide the strength needed in high pressure equipment. High tensile strength with tough threads offers maximum holding power and resistance to wear. Tighten smoothly, back-off easily. Send coupon today.

SPECIFY REPUBLIC SRK PLASTIC PIPE for a variety of oil and natural gas handling where corrosion is a factor. Republic SRK is lightweight for low-cost shipping and easy handling. It is easy to cut, join, and make a permanent installation fast. Send for literature.

POSITIVE SHIPPING PROTECTION—Republic offers a full range of barrels, drums, and pails in many styles and sizes up to 55 gallons—ENDURO® Stainless Steel, galvanized and tinned steels, open-hearth steel—plain, lacquered, decorated. Send coupon today.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. PR 7855-R
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send information on the following Republic products:

☐ ELECTRUNITE Heat Exchanger Tubing ☐ Carbon ☐ Stainless
☐ SRK Plastic Pipe ☐ Steel Drums ☐ Shipping Containers
☐ Alloy Steel Studs ☐ High Carbon Hex Nuts

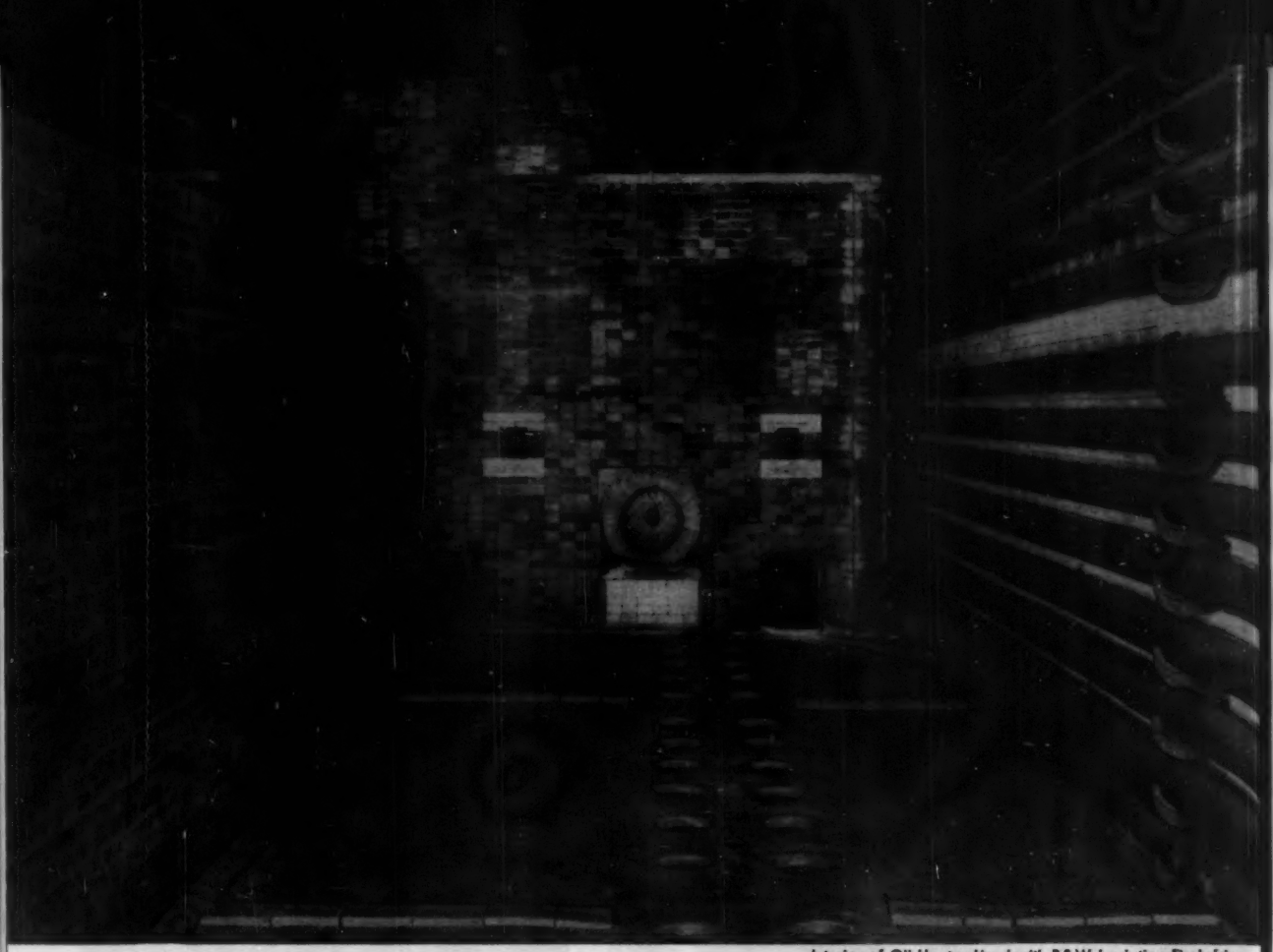
Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

For more data on advertised products, use Readers' Service Cards, last page.



Interior of Oil Heater Lined with B&W Insulating Firebrick.

B&W Refractories stay on stream

Long refractory life, low furnace maintenance, and dependable service result from the use of B&W Refractories. B&W offers a wide line of *specialized* refractories *engineered* to give you maximum furnace availability and economy.

Naturally, the refractory selected depends on the specific service. B&W Insulating Firebrick, for example, serve a dual role. First, these durable, lightweight IFB are most efficient insulators, and second, they withstand direct exposure to furnace heat. This means . . .

REDUCED CONSTRUCTION COSTS—The lightweight and high insulating value of B&W IFB combine to lower material costs and simplify furnace design. Because they withstand furnace heat, they eliminate the need for dense refractory constructions backed up with insulating materials. This, together with lightweight, means thinner, lighter wall constructions, often providing savings in structural steel and foundation costs.

REDUCED OPERATING COSTS—The high insulating value of B&W IFB means savings in everyday operation. Per inch of thickness, B&W IFB provide more insulation than any other refractory lining. Less heat is lost, casing temperatures are lower, working conditions are improved and efficiency is increased.

Furthermore, since B&W IFB are light in weight, they store and conduct less heat. Heavy refractories retain heat; in the event of forced shutdown, they can cause burn-out of expensive alloy tubes, where used. The low quantity of heat stored by B&W IFB can be quickly dissipated, thus protecting these expensive tubes.

This low heat storage also permits faster heating and cooling. This means quicker access to the furnace in the event of emergency shutdown. Your maintenance crew can get in the furnace sooner and get it back on stream faster.

Consult your B&W Refractories Representative for assistance with your refractories problem or write to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

B&W

THE BABCOCK & WILCOX COMPANY

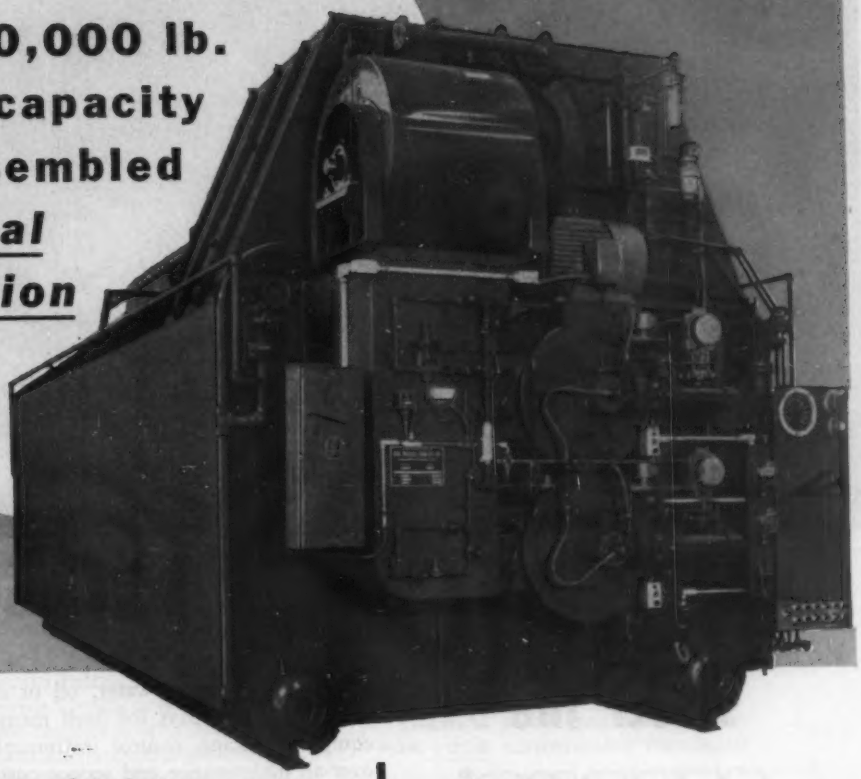
REFRACTORIES DIVISION

R-529

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

...now from WICKES

a new 100,000 lb. per hour capacity shop-assembled *natural circulation* boiler



Wickes Type A units are of simple design, ruggedly constructed and adaptable to a variety of operating conditions and may be fired with oil, gas or combination of both.

All units are shipped completely shop-assembled including superheater, fuel burning equipment, safety and combustion controls, forced draft fan and drive, soot blowers and feedwater regulator.

Save on

- First Cost
- Operating Expense
- Space
- Delivery Time
- Installation Time

For more detailed information on Wickes Type-A steam boilers, write for our catalog 56-1. Bulletin 55-1 covers the complete line of Wickes Products and Facilities.

WICKES type A

WICKES

WICKES BOILER CO., SAGINAW 18, MICHIGAN

DIVISION OF THE WICKES CORPORATION

RECOGNIZED QUALITY SINCE 1854 • *SALES OFFICES:* Boston • Chicago • Cleveland • Dallas • Denver • Detroit • Houston • Indianapolis • Los Angeles • Memphis • Milwaukee • New York City • New Orleans • Portland, Ore. • Saginaw • San Francisco • Springfield, Ill. • Tulsa.

169-R

STRONG strainers in condensate line in new Cleveland skyscraper.

select the STRONG® strainer designed for you!

IN steam, air, gas, water, oil or chemical systems, a *correctly selected* strainer pays for itself many times. It protects expensive equipment (traps, control instruments, meters, etc.) and reduces over-all maintenance and service costs.

Assure your system maximum protection from dirt, scale, sludge and sediment . . . specify *the* STRONG strainer designed for your requirements.

Sizes: from ¼" to 8"

Service: 250 psi at 450° F to 2500 psi at 1100° F

Screens: stainless screens with .027", .045", .062", or .125" perforations (at no extra cost)

Types: "Y" or Angle with screwed or socket-weld (flanged) connections

Materials: semi-steel, ductile-iron, bronze, Monel, cast or block steel, or new all-stainless or Hasteloy

STRONG'S extensive line of rugged, high-quality strainers are available from your local STRONG distributor. Contact him for assistance in selecting the *right* strainer, or write for your copy of STRONG Bulletin SS—21C.

STRONG, CARLISLE & HAMMOND

508 Sandusky Street, Conneaut, Ohio

air traps • strainers • reducing valves • vacuum or pumping traps
continuous blowdown valves • separators • engine stops • F and T traps • safety headgear

another
TRETOLITE SERVICE
report

BEFORE KONTOL! *Here's what a tube bundle looked like in one of the heat exchangers of an Ohio refinery — after just 94 days of service. A* KONTOL *Protection Program has since trebled tube life, upped heat exchange efficiency by more than six million BTU's per hour!*

KONTOL* CORROSION INHIBITOR TRIPLES TUBE-BUNDLE LIFE AT OHIO REFINERY

Also saves $96.00 per day on increased BTU's . . . The effectiveness of KONTOL* protection against corrosion and fouling in tube bundles was dramatically demonstrated in the heat exchange equipment of the crude unit at a large refinery in Ohio.

Since the inauguration of a regular KONTOL Corrosion Inhibitor program, the tube bundle life period has been increased by approximately 3 times the bundle life prior to the use of KONTOL.

KONTOL'S DETERGENT ACTION ADDS DOLLAR-BONUS TO OPERATION

The detergent action of KONTOL Corrosion Inhibitor provided a *plus* benefit for the refinery. A cleaner operation has resulted in the gain of an additional 6,000,000 BTU's per hour—or a savings of about $96.00 per day.

THERE'S A KONTOL PRODUCT FOR YOUR CORROSION PROBLEM

The KONTOL product used in this case was based on a careful study of the refinery's specific needs. The Tretolite Company developed and pioneered the application of organic corrosion inhibitors throughout the petroleum industry. No other organization has Tretolite's wealth of experience and know-how in the manufacture and use of these products. This background (Tretolite corrosion engineers, laboratory and research facilities) is always available to you—to help solve your particular corrosion problems. A call will bring you this service—at no obligation.

*KONTOL *is a registered trademark of Petrolite Corporation.*

KR-59-1

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CORPORATION

TRETOLITE COMPANY
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COLOMBIA: South American Petrolite Corporation, Calle 19, No. 7-30, Office 807, Bogota

ENGLAND: Petrolite Limited, 46 Mount Street, London W. 1.

VENEZUELA: South American Petrolite Corporation, Hotel Avila, Caracas

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For more data on advertised products, use Readers' Service Cards, last page.

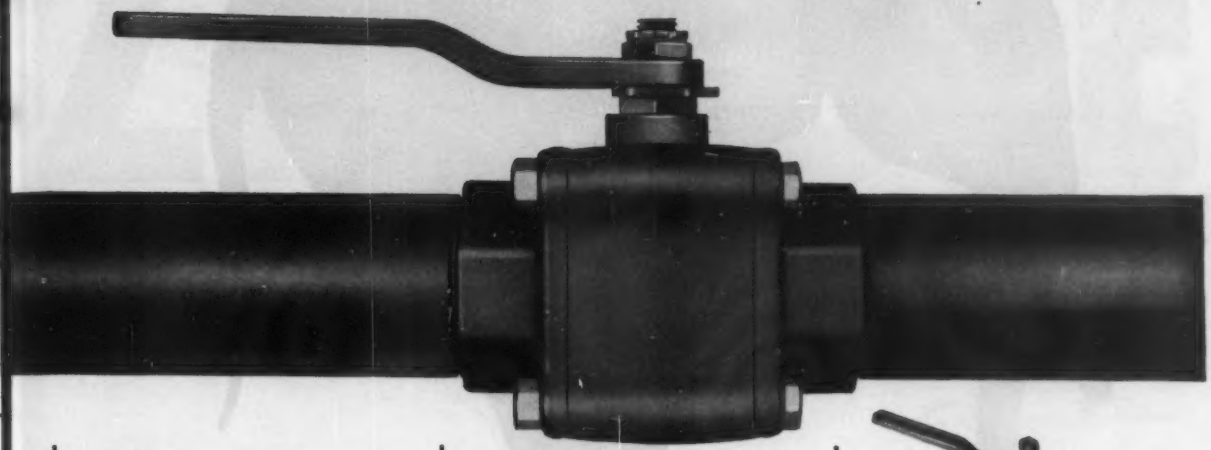
COMPARE . . .

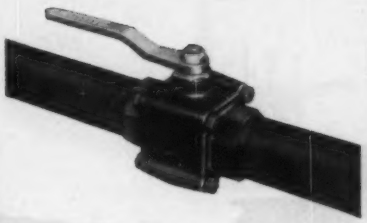
	ECON-O-MISER	GATE VALVE	FLANGED GATE VALVE	DIAPHRAGM VALVE	LUBRICATED PLUG VALVE
FLOW CHARACTERISTICS	Smooth round flow	Turbulence results in excessive pressure drop	Turbulence results in excessive pressure drop	Turbulence results in unusually high pressure drop	Constricted flow . . . pressure drop
SPEED OF OPERATION	CLOSED ¼ turn operation OPEN	2½ to 3½ turns of hand wheel	2½ to 7 turns of hand wheel	2½ to 3½ turns of hand wheel	¼ turn operation
MAINTENANCE CHARACTERISTICS	Seats and "O" Rings easily replaced	Valve normally thrown away	30% to 50% of purchase price	In-line maintenance possible	Regular lubrication necessary to maintain seal
SIZE FACE TO FACE	CENTER TO TOP—OPEN 3 1/16	12 3/8	16 1/2	7 1/4	10 1/2
LIFE EXPECTANCY	Half million cycles not unusual	Metal-to-metal seating limits life	Metal-to-metal seating limits life	Better than gate valve	Very good if lubricated regularly

THE ECON-O-MISER BALL VALVE IS THE IDEAL REPLACEMENT FOR MOST ON-OFF VALVES NOW IN USE IN THE PROCESS INDUSTRIES!

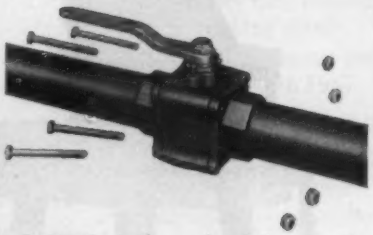
MORE EFFICIENT . . . LESS COSTLY

THE ECON-O-MISER BALL VALVE

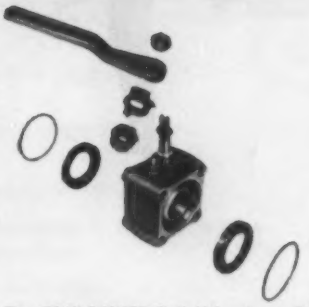




Compact, efficient ECON-O-MISER Ball Valves are today's smoothest operating on-off valves. A quarter turn of the handle allows full operation and you can tell at a glance whether the valve is open or closed. More . . . ECON-O-MISER Ball Valves act as both valve and union . . . eliminate costly inventory and labor. Minimum turbulence and greater economy make this valve ideal for hundreds of applications.



Remove four nuts . . . four bolts . . . and the entire center section lifts out for servicing. Quick, convenient maintenance saves money **and** this unique design means pipe ends never have to be removed from the line. Seating surfaces and O-Rings are easily replaced . . . whole valve back in operation in minutes. Reduces inventory expenses and frees maintenance personnel from time consuming repairs.



The ECON-O-MISER Ball Valve is available in many combinations of seats, O-Rings and body materials. Almost any media can be handled by the ECON-O-MISER and sizes range from ¼" through 6". Made of bronze, aluminum, carbon steel, stainless steel or aluminum bronze. We'll be happy to furnish information or application data.

THE ONLY VALVE IN INDUSTRY THAT SERVES AS BOTH VALVE AND UNION!

Complete, technical information in new "Comparison" bulletin.

Request EB 101 on your letterhead or fill in coupon.

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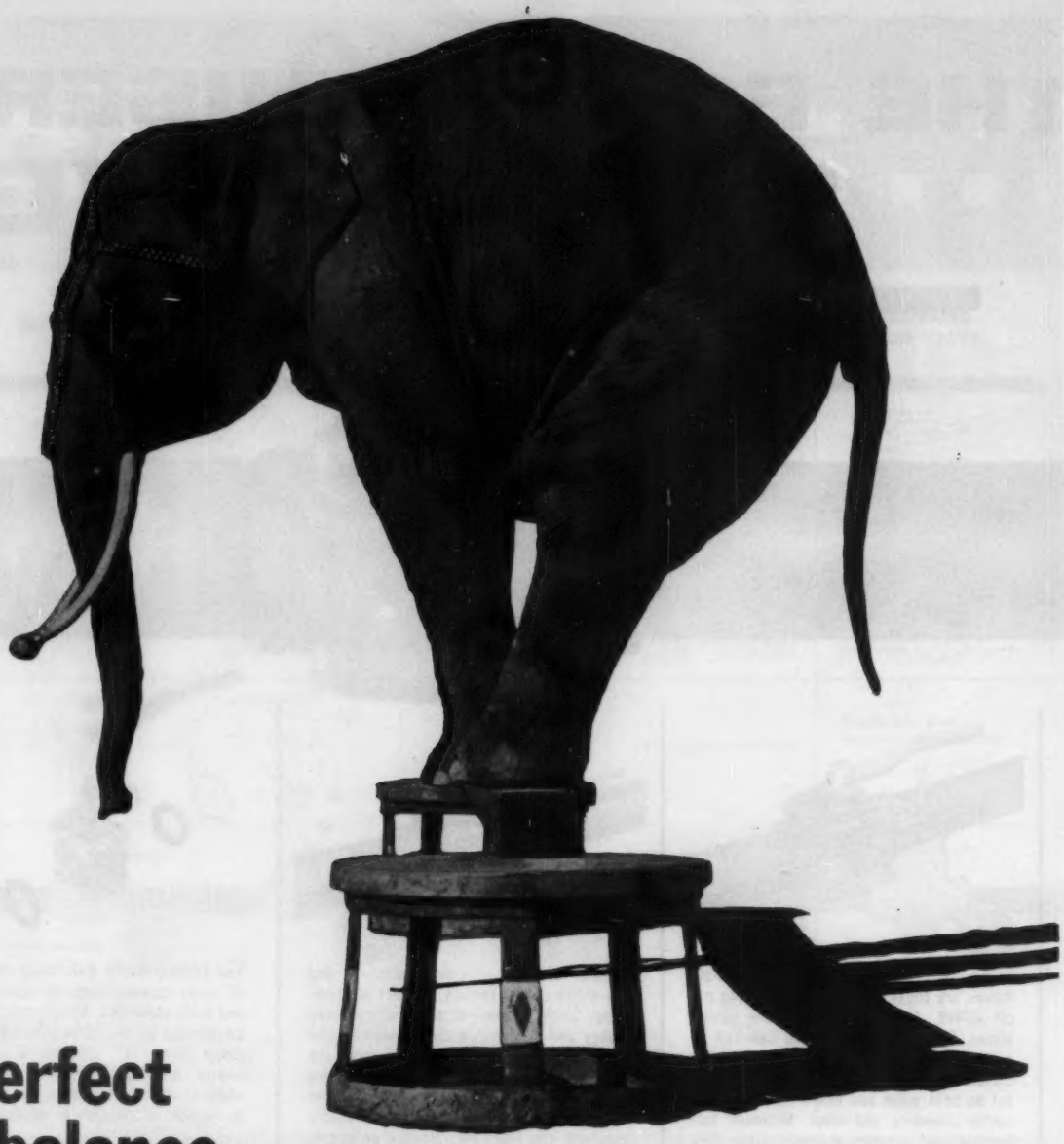
☐ Please forward bulletin EB 101. ☐ Please ask sales engineer to call for appointment. ☐ Send information on ECON-O-MISER FLANGE BALL VALVE.

WORCESTER VALVE CO., INC.

DEPT. B • 16 PARKER STREET • WORCESTER, MASS.



Perfect balance of skill and experience commends the Mitchell organization to your interest regarding your next job of critical piping. If you know the wisdom of delegating the prefabricating and erecting of high-pressure, high-temperature piping *directly* to specialists... by all means ask us in.

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Philadelphia 46, Pa.

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MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS

from the makers of Dimetcote...

ZINKOTE®

THE FIRST 100% INORGANIC *SELF-CURING* ZINC COATING.

- A radically new concept in zinc coatings for protecting steel.
- Under development for many years and first patented in 1957.
- Applied in one coat – completely self-curing.
- Can be used wherever galvanizing is satisfactory – actually gives superior protection.
- Completely nonflammable, nontoxic.
- Insoluble in all petroleum products.
- Outstanding resistance to weathering, salt and fresh water.
- Applied by brush, spray or roller.
- Cathodically protects steel.
- Resists temperatures up to 600°F.
- Complete protection for as little as 5¢ per square foot material cost.

For complete information write . . .

How does Zinkote compare with Dimetcote? Although similar, each has certain unique advantages depending upon the particular requirements of the job. We will be glad to give you a specific recommendation.

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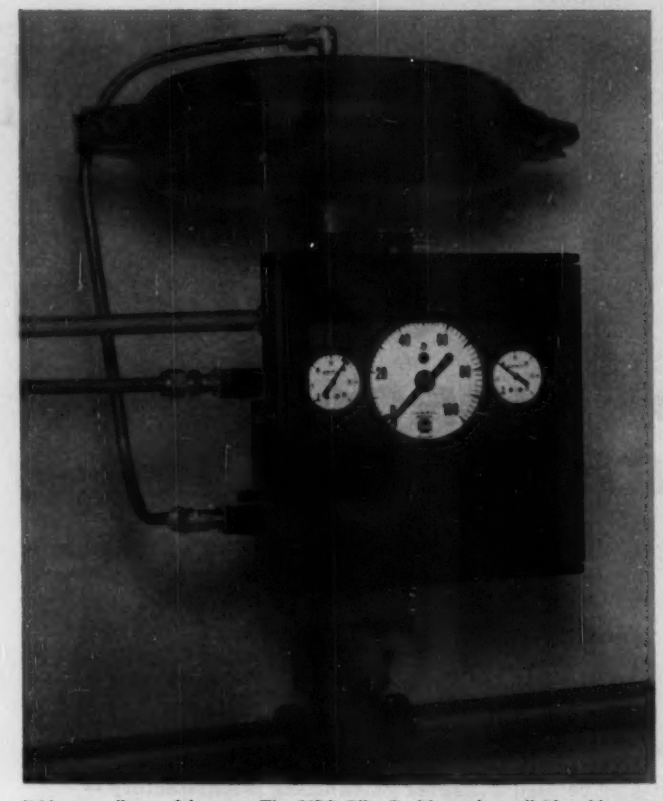
921 Pitner Ave. Evanston, Ill. | 360 Carnegie Ave. Kenilworth, N.J. | 2404 Dennis St. Jacksonville, Fla. | 6530 Supply Row Houston, Texas

The Pioneer Manufacturer of Inorganic Zinc Coatings

New...from United States Gauge!

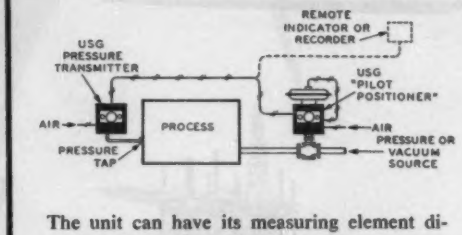


Wide controller model range. The USG Pilot-Positioner is available with most controller models in the USG Pilot line. These include pressure measurement from 30 in. Hg vacuum to 10,000 psi (applicable to liquid level as well), and temperature measurement from —350F to 1000F. Also, proportional band, adjustable for 0 to 75%, or adjustable differential gap (for fast-stroking valve). Unit measures a compact 8½ in. square.

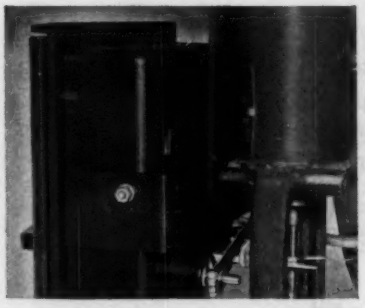
USG CONTROLLER AND VALVE POSITIONER COMBINED!

. . . in low-cost, valve-mounted U.S. Gauge Pilot-Positioner

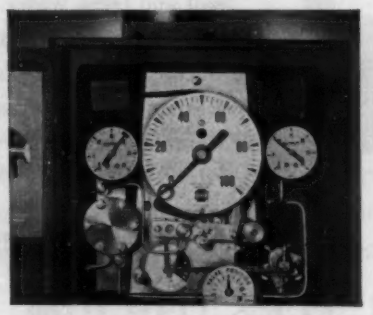
First practical combination of an indicating pneumatic controller and a valve positioner. One compact unit for temperature or pressure control and quick, accurate valve positioning. Check details here. Then send for Bulletin FO29 today!



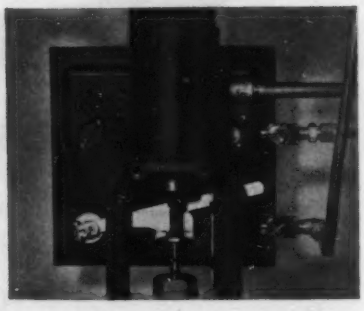
The unit can have its measuring element directly connected to the process. Or, as shown in diagram, it can be a pneumatic receiver for use with all makes of pneumatic transmitters. This permits additional indicating or recording at a remote panel board, as well as indication of the variable at the valve.



Eliminates second unit! Valve-mounted close to the process, the USG Pilot-Positioner minimizes transmission lags, provides higher precision and speed in valve action. Need for separate valve positioner is eliminated, cutting initial cost of two controls and saving on installation and maintenance. Unit fits any standard diaphragm motor valve.



New non-bleed relay. Faster, more accurate and positive positioning action is assured with a new USG-designed, high capacity non-bleed relay. A control by-pass panel with manual-automatic-service positions is offered as an option, mounting underneath the instrument case. Another option permits remote pneumatic set point adjustment.



Mechanical feedback; one air supply. The new Pilot-Positioner employs mechanical feedback through a lever system. Controller's pneumatic components are used to amplify air pressure. Only one air supply required and pressure can be as high as 65 psi. Adjustable for valve stem travels from ⅜ in. to 4 in. Valves can be air-to-open or air-to-close.

Find Your Nearest Distributor in The 'Yellow Pages'

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USG®

How Foster Wheeler gives you "profits" from chemicals you don't make

It's a matter of getting full value out of ideas . . . because ideas that start with one chemical product or process can often make another *different* product or process better, or more profitable.

Today, for instance, one producer of *methanol* is enjoying benefits of "profit ideas" based on FW's experience in combining methanol and ammonia synthesis. Another example, FW's design for production of high quality phthalic anhydride makes possible new profit-making efficiency for plants with capacities of three tons per day or more.

Find out about these and many other "profit ideas" FW can offer, by writing to Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N.Y. Ask for the new booklet about "The Plant You Want to Build".

Heat Engineered products, plants and processes . . . for the world's industrial progress.

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

—petroleum processing —chemical processing —specialized installations

SMITH FLANGED END VALVES

A WHALE OF A VALUE for THREE BIG REASONS

THEY'RE
LOWER
IN SILHOUETTE
LIGHTER
IN WEIGHT . . . AND
CHEAPER TO OPERATE

Smith FORGED STEEL Valves

Because they are lower in height and lighter in weight than competitive valves, SMITH Flanged End Valves are much easier to handle and install. What's more important, they have a combination of special built-in features which insures longer, trouble-free life in service with very low maintenance cost.

Like all SMITH Valves, these flanged ends can really "take it." That's why SMITH Valves are on the preferred list in a large percentage of the major refineries, chemical and petrochemical plants in this country and Canada. For complete information including material and dimension specifications, write for brochure #1536A.

150 lb. — 300 lb. — 600 lb. series — to A.S.A. face-to-face dimensions

SMITH FORGED STEEL FLANGED END VALVES
Meet A.S.A. face-to-face dimensions and are available in #150, #300 and # 600 series, sizes ½" — 2" inclusive

NEW ENGLAND VALVE Corporation

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WORCESTER
MASSACHUSETTS

New England Valve Corp.
of Canada Ltd.
Factory & Offices: 1 Seneca Avenue
Port Credit, Ontario

tame HF for alkylation economies

...Pennsalt service helps you do it

Why not cash in on the advantages of hydrofluoric acid alkylation? Simple catalyst regeneration gives you lower acid consumption per barrel of alkylate . . . eliminates spent acid problems and large acid inventories. HF lets you use water as your coolant . . . reduces cooling equipment expense. It gives you shorter reaction time and catalyst settling time. Getting these economies is easy. Here's why.

Expert technical aid from Pennsalt shows you how to handle HF safely . . . just as safely as many other active chemicals you're already using. We'll advise you on HF storage, and on piping, valves and other equipment and materials . . . help you with employee training programs. We can give you this service because . . .

Pennsalt specializes in HF. We've pioneered in making, shipping and storing it better, safer and more economically. The purity of Pennsalt® HF meets or surpasses alkylation process requirements. Ample supplies are available, in cylinders and tank cars of convenient sizes. Write or call for more information or ordering.

See our Catalog in Chemical Materials Catalog

INDUSTRIAL CHEMICALS DIVISION

PENNSALT CHEMICALS CORPORATION

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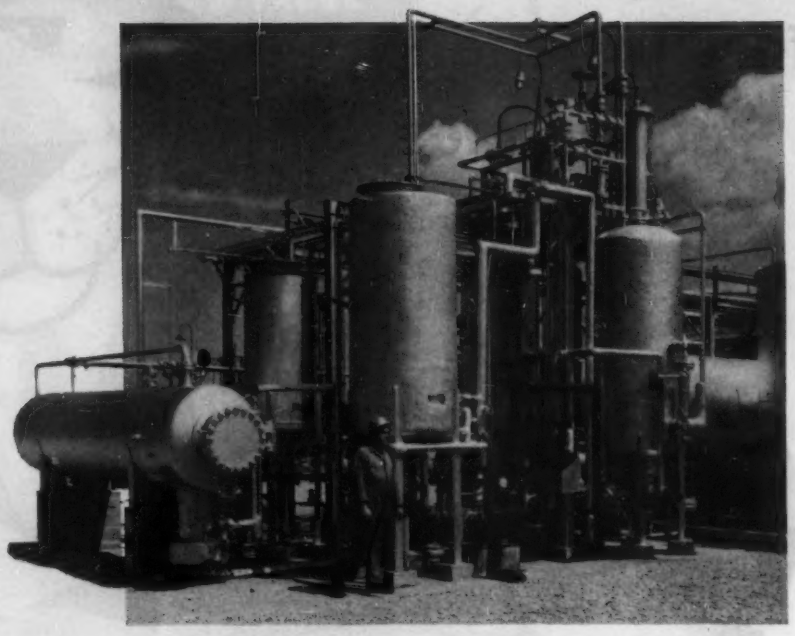
Pennsalt Chemicals ESTABLISHED 1850

In the West, Pennsalt inorganic chemicals are available through Pennsalt of Washington Division, with plants at Tacoma, Washington and Portland, Oregon.

PRODUCT IMPROVEMENT WITH **PETRECO**



Let's get together on your next separation problem!

ELECTROFINING* Precipitation Equipment has been helping to solve treating and separation problems in the petroleum industry for many years.

Properly applied, it efficiently separates one liquid phase from another, and is being widely used today to contact or "scrub" hydrocarbons with chemicals in aqueous solution, acids, caustics and doctor solutions, to name a few.

Such contact is carried on in a closed system. Controls are set after the most effective treating conditions have been established by pilot testing; treatment is completely automatic.

In any operation where the mixing of two immiscible liquids is necessary, the formation of stable emulsions is always a possible complication. ELECTROFINING Precipitation Equipment demulsifies and separates such phases quickly, cleanly and without entrainment, provided the external phase is nonconductive and the dispersed phase conductive.

IF A SEPARATION PROBLEM IS PLAGUING YOU, we'd like to have the opportunity to sit down and discuss it with you. Or, if you prefer, write us first—describing your problem, product and type of operation. There's no cost or obligation, of course.

*"ELECTROFINING" *is a registered trademark of Petrolite Corporation*

CP-59-1

PETROLITE CORPORATION

CANADA: Petrolite Corporation of Canada, Limited, 4528 Stanley Drive, Calgary, Alberta

ENGLAND: Petrolite Limited, Heathcoat House, 20, Savile Row, London W. 1.

VENEZUELA: South American Petrolite Corporation, Hotel Avila, Caracas

REPRESENTATIVES

BRAZIL: WERCO, Ltda., Avenida Rio Branco 57—s/1410-11, Rio de Janeiro

COLOMBIA: W. F. Faulkner, Calle 19, No. 7-30, Office 807, Bogota

ITALY: O. Wagner, 149 Via Nemorense, Apt. 1, Rome

JAPAN: Chiyoda Chemical Engineering and Construction Company, Ltd., Tokyo Bldg., No. 3, Marunouchi 2-Chome, Chiyoda-Ku, Tokyo

KUWAIT: F. N. Dahdah, Box 1713, Al Kuwait

MEXICO: R. E. Power, Sierra de Mijes, No. 125, Mexico D. F.

NETHERLANDS: F. E. C. Jenkins, Hoefbladlaan 134, The Hague

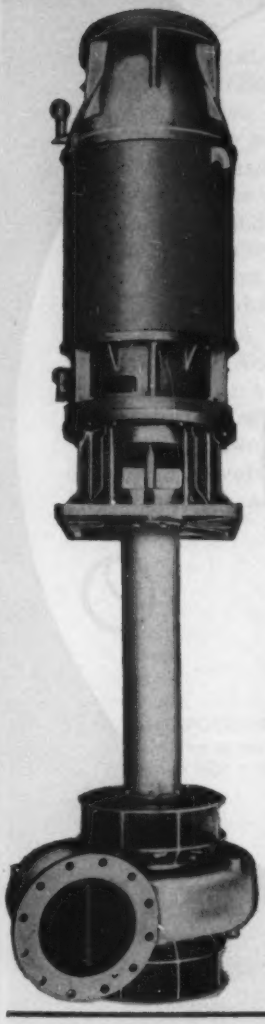
TRINIDAD: Neal and Massy, Ltd., P. O. Box 544, Port of Spain

PETRECO
DIVISION
3202 South Wayside Drive (P.O. Box 2546), Houston 1, Texas
1390 East Burnett Street (P.O. Box 7216), Long Beach 7, California

Bingham

TYPE "VS"
DOUBLE SUCTION
DOUBLE VOLUTE
VERTICAL PUMP

REDUCES COSTS WITH SHALLOW PIT LOWER MAINTENANCE



SPECIALLY DESIGNED FOR WET-PIT SERVICES. COOLING TOWER, SPRAY POND, DISPOSAL SUMP, WATER SUPPLY, DRAINAGE — AND OTHER HIGH-CAPACITY, MEDIUM-HEAD WET-PIT SERVICES.

The BINGHAM "VS" Pump, which is an advanced design of a "Double Volute"—"Double Suction" single stage pump, saves money in three ways: (1) Lower installed cost because it does not require a deep pit and can use standard motors. (2) Lower operating cost, because it operates at higher efficiencies, uses less power. (3) Lower maintenance cost, because there is no stuffingbox, all bearing loads are light, and the installation is easy to inspect and service.

The "Double Volute" construction of the "VS" Pump maintains radial balance of its rotating element throughout the entire operating range of the pump. Wear due to "Side Push" is eliminated.

The "Double Suction" feature of this pump eliminates axial hydraulic thrust, thereby permitting the use of standard vertical motors.

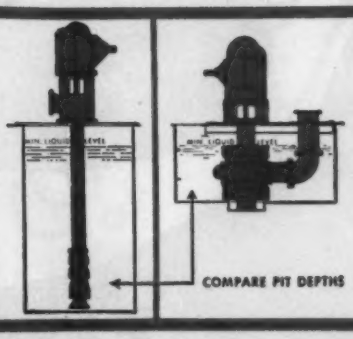
These and many other important reasons make the BINGHAM "VS" Pump the most logical choice today for wet pit service. For full details call your nearest Bingham Office or write for Bulletin No. 110.

A Battery of Bingham "VS" Pumps Operating at a major Gulf Coast gas processing plant.

COMPARE THESE PITS FOR COST

OLD

Conventional Deep-Well Turbine Pump Installation . . . requires the pit be deep enough to maintain sufficient pumpage above the pumping element in order to provide the required NPSH.



COMPARE PIT DEPTHS

NEW

Bingham "VS" Pump Installation . . . requires only a shallow pit and only sufficient pumpage to cover the pumping elements. Pit construction is thereby *greatly reduced.*

Bingham SINCE 1921

DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY

General Offices: **2800 N.W. Front Avenue, Portland 10, Oregon**

Factories: **Portland, Ore. • Vancouver, B. C., Canada**

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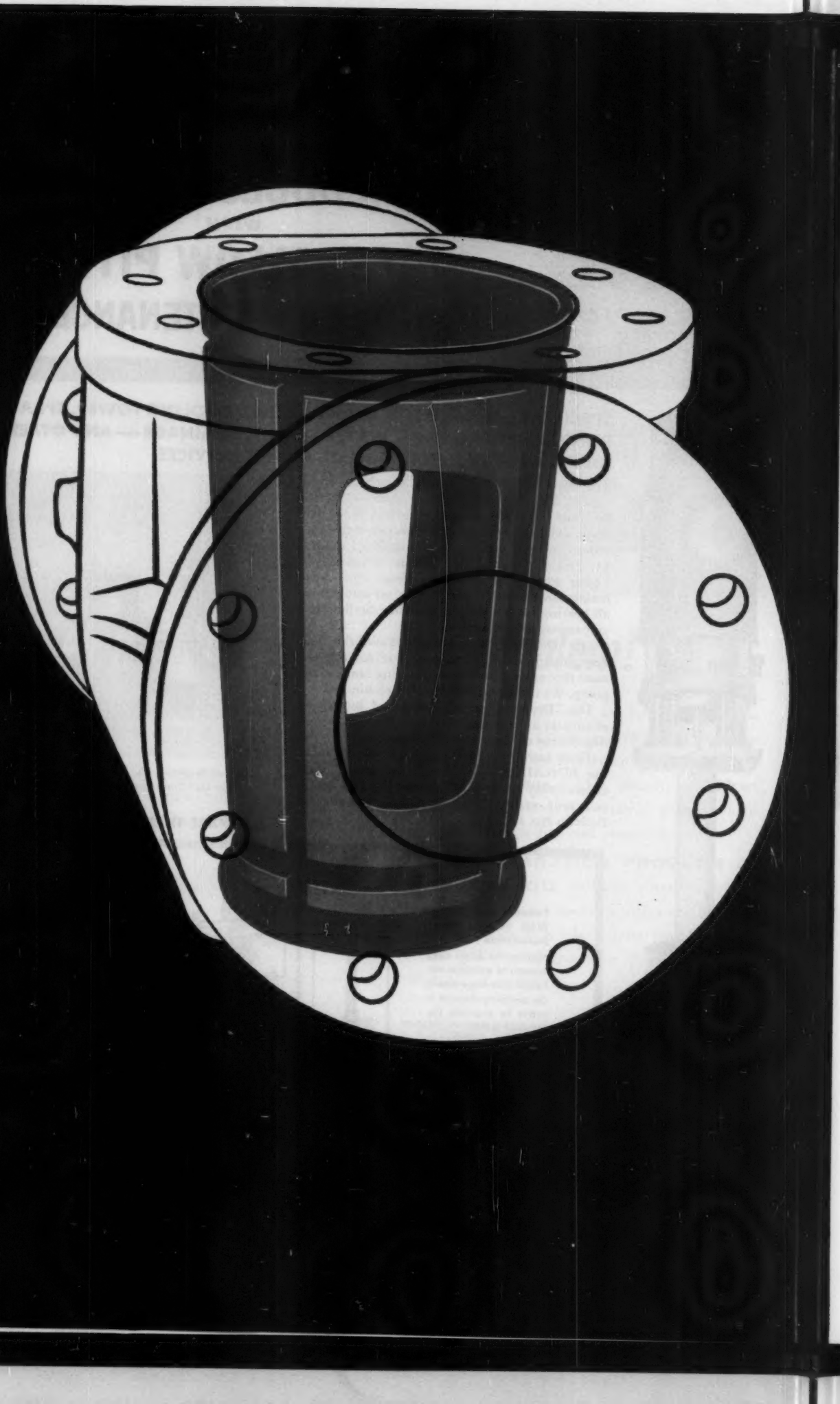
TORONTO, ONT., CAN.
VANCOUVER, B. C., CAN.

For more data on advertised products, use Readers' Service Cards, last page.



This valve seat repairs itself

You Can't Cut, Scratch or Warp it!

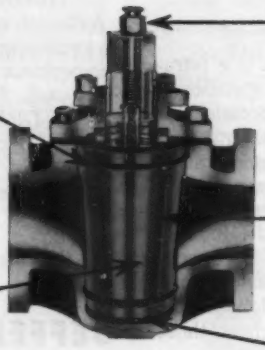
You're looking at a phantom view of the *pressurized lubricant* Sealdport® system in a Rockwell-Nordstrom valve. This pressurized lubricant is actually a *basic part* of the valve . . . it's the "part" that makes the big difference in terms of giving you longer valve life, tighter shut-off, and unequalled dependability.

Lubricant sealing in the exclusive Sealdport® system is the most simple yet effective valve seal imaginable. Under pressure, the lubricant becomes a powerful, impenetrable seal between the plug and body. And, much like a self-sealing auto tire, this seal can't be permanently cut, scratched or damaged. It actually *repairs itself.*

You'll get two other important advantages over ordinary valves when you specify Rockwell-Nordstrom: *dependability* and *economy.* Lubrication makes the difference again by eliminating the metal-to-metal wearing friction that ruins ordinary "dry" valves so quickly. And lubricant hydraulically "cushions" the plug for fast, easy ¼-turn operation.

Try just *one* Rockwell-Nordstrom valve and you will see why over 6,000,000 are in use today. You can have a Rockwell Field Engineer visit you with complete details by writing: Rockwell Manufacturing Company, Pittsburgh 8, Pa. *Canadian Valve Licensee:* Peacock Brothers Ltd.

ROCKWELL-Nordstrom VALVES
another fine product by
ROCKWELL



UNEXPOSED SEATING can't be corroded or eroded by line materials or high pressures.

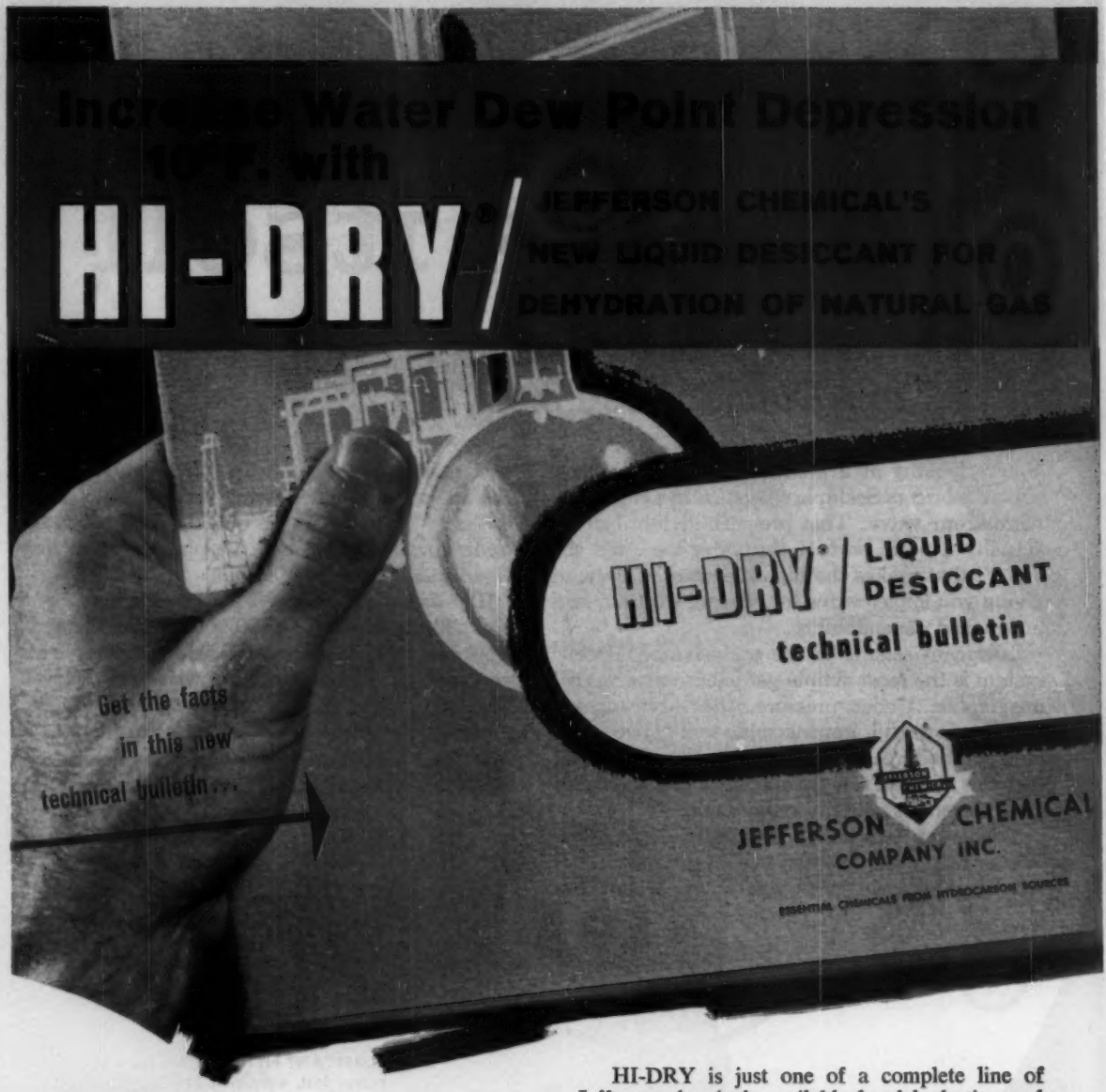
LUBRICANT FITTING makes lubrication fast, easy and simple . . . valve can be lubricated or adjusted while in operation.

LEAKPROOF SEALING is insured by pressurized lubricant in Sealdport® sealing grooves . . . seats can't be cut, scored or warped.

WEAR IS ELIMINATED by film of lubricant on all vital surfaces.

HYDRAULIC JACKING of lubricant pressure keeps plug free for instant, quarter-turn operation.

Lubrication makes the difference . . . . .



HI-DRY® brand liquid desiccant is a tetraethylene glycol concentrate developed specifically to give you the extra dew point depression so often needed in the dehydration of natural gas. Extensive field tests indicate that reconcentration of HI-DRY at 435°F. and triethylene glycol at 375°F. are comparable in level of thermal stability. The lower vapor pressure of HI-DRY, in addition to the increased degree of reconcentration achievable due to its greater thermal stability, offers an advantage in the dehydration of higher temperature gas streams such as those experienced at compressor stations.

Provided in this new HI-DRY technical bulletin are sales specifications, shipping information, typical applications and physical properties. From the physical properties you may readily estimate the results obtainable with various operating conditions.

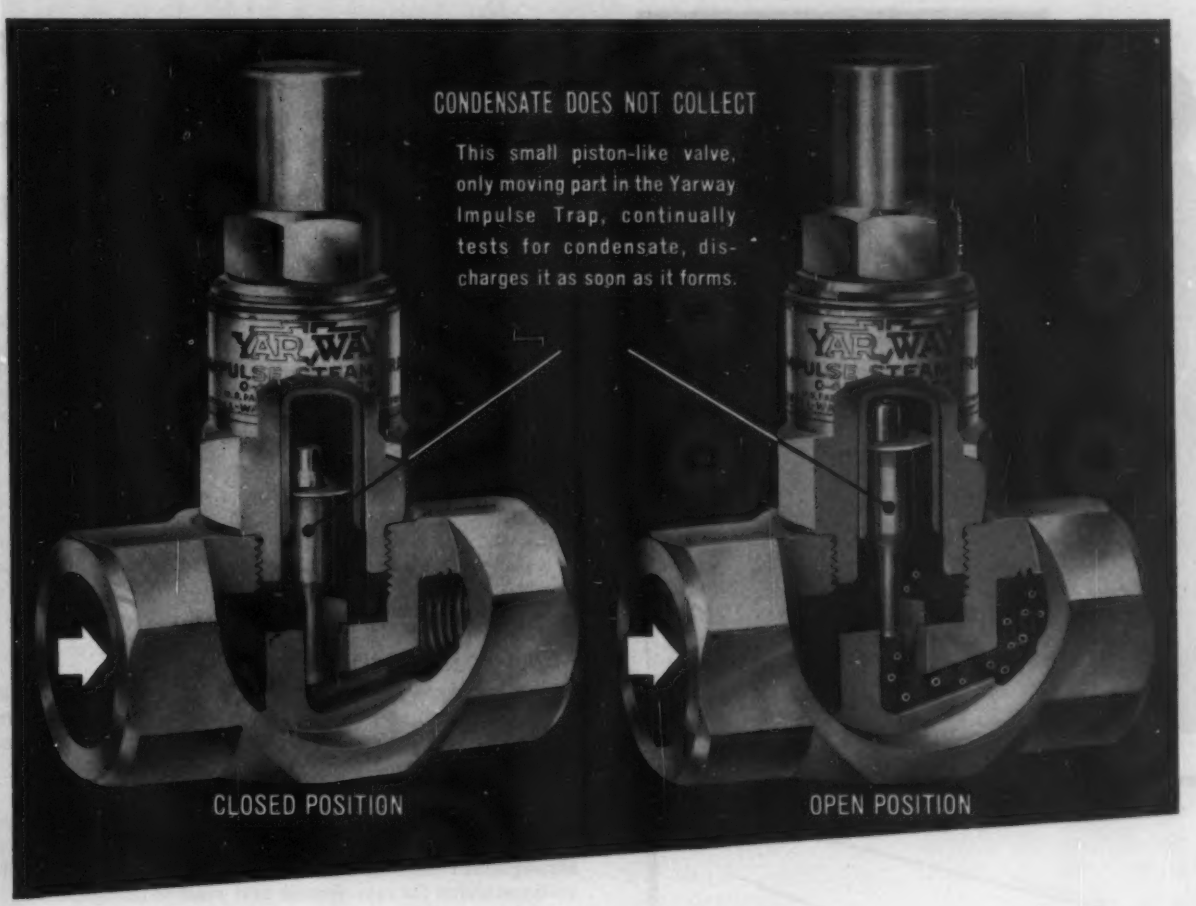
HI-DRY is just one of a complete line of Jefferson chemicals available for dehydration and sweetening. Jefferson's extensive background of experience in gas treating processes is at your disposal. For helpful technical services, samples of HI-DRY liquid desiccant, or the new HI-DRY technical bulletin . . . contact Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

JEFFERSON® CHEMICAL COMPANY, INC.

HOUSTON • NEW YORK • CHICAGO • CLEVELAND
CHARLOTTE • LOS ANGELES

Ethylene and Propylene Oxides, Glycols, Dichlorides • Ethanolamines
Morpholine • Piperazine • Polyethylene Glycols • Nonyl Phenol
SURFONIC® Surface-Active Agents • Ethylene and Propylene Carbonates
Caustic Potash • Caustic Soda • Soda Ash • Sodium Bicarbonate

Essential Chemicals From Hydrocarbon Sources


CONDENSATE DOES NOT COLLECT
This small piston-like valve, only moving part in the Yarway Impulse Trap, continually tests for condensate, discharges it as soon as it forms.
CLOSED POSITION
OPEN POSITION

Yarway Impulse puts the heat on steam trap freeze-up problems

Cold weather means nothing to a Yarway Impulse Steam Trap. *Its design offers full protection against freeze-ups,* with resulting costly production delays and extra maintenance work.

In the Yarway Impulse Trap there's nothing to freeze. No condensate collects. The only moving part (a tiny piston-like valve) continually tests for condensate and discharges it as soon as it forms. Result—continual operation of steam equipment at high, even temperatures.

Consider this non-freeze feature with these other Yarway Impulse features:

- **Quick heat-up**
- **Low maintenance**
- **Stainless steel construction**
- **Small size—light weight**
- **Good for all pressures**
- **Complete line for all requirements**

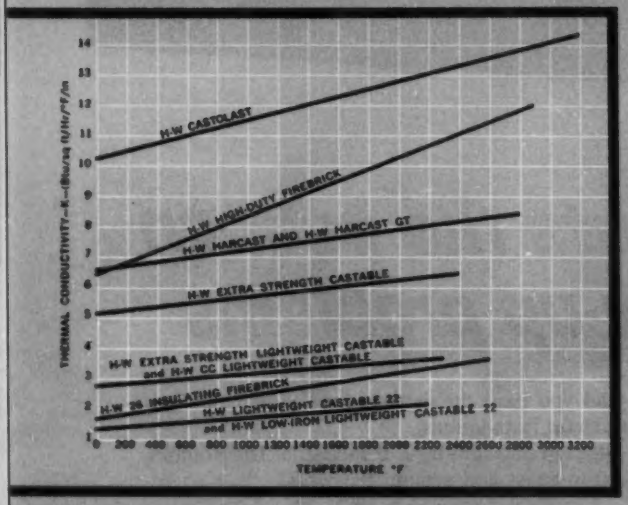
—and you have the reasons for nearly 1,300,000 successful installations.

Stocked and sold by 270 Industrial Distributors, coast-to-coast and around the world.

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY
A MARK OF QUALITY IN STEAM ENGINEERING

For more data on advertised products, use Readers' Service Cards, last page.


THERMAL CONDUCTIVITY—K—(Btu/sq ft/hr/°F/in
H-W CASTOLAST
H-W HIGH-DUTY FIREBRICK
H-W HARCAST AND H-W HARCAST GT
H-W EXTRA STRENGTH CASTABLE
H-W EXTRA STRENGTH LIGHTWEIGHT CASTABLE and H-W CC LIGHTWEIGHT CASTABLE
H-W 26 INSULATING FIREBRICK
H-W LIGHTWEIGHT CASTABLE 22 and H-W LOW-IRON LIGHTWEIGHT CASTABLE 22
TEMPERATURE °F

This Useful Chart—indicating service limits and comparative thermal conductivities (along with a table of physical properties)—is included in a newly-published brochure, "Harbison-Walker Refractories for the Petroleum Refining and Petrochemical Industries."

For Maximum Resistance to HARBISON-

for every petroleum refining

H-W CASTABLE REFRACTORIES

They comprise all commercial classes. Proper brand selection provides the best combination of physical and chemical properties for specific applications—assuring maximum life and economy. Installation may be by various methods—gunning, trowelling, pouring or tamping—depending upon composition and application.

H-W CASTOLAST

This extremely high-purity, low-iron castable consists of accurately grain-sized tabular alumina and low-iron calcium-aluminate binder. It develops high strength throughout its temperature range, is unaffected by reducing atmospheres, and is very abrasion resistant. It is excellent for lining catalytic vessels, butadiene reactors, feed lines and cyclones.

H-W HARCHROME

This extra strength chrome-base castable with hydraulic binder takes an extremely hard, strong set. It is especially designed for maximum wear resistance in feed lines and cyclones of catalytic cracking units.

H-W EXTRA STRENGTH CASTABLE

A blended mixture of carefully sized hard-fired refractory aggregates, bonds and hydraulic binders, this product is strongest of all regular fireclay castables. It is highly recommended for regenerator and reactor linings, catalyst feed lines, cyclones, doors and sub-bottoms of various types of furnaces, and patching worn brickwork.

H-W HARCAST AND H-W HARCAST GT

These castables are manufactured from super-duty calcined fireclay carefully combined with high-purity plasticizers and hydraulic binders. The iron content in each is less than 1%, which adequately meets the specifications of petroleum companies. They are used where platinum catalysts are employed and provide exceptional strength at all temperatures up to their service limits.

H-W LIGHTWEIGHT CASTABLE 22

(Former brand name—H-W 56 Lightweight Castable)

A quality-controlled mixture of lightweight aggregates and hydraulic binders, it combines light weight and strength to utmost degree, has very low thermal conductivity and serves as an ideal insulation behind hard surface abrasion-resistant castables or brick. It gives outstanding service in regenerators and reactor linings, ducts and breechings, boiler wall backing and tube decks, air preheater linings, heater walls, roofs and door linings.

HARBISON-WALKER REFRACTORIES COMPANY

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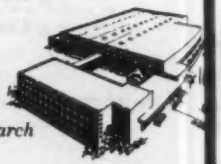
GENERAL OFFICES: PITTSBURGH 22, PA.

World's Most Complete Refractories Service

The Garber Research Center



Leadership in refractories through constant research

Corrosion, Abrasion, Reducing Atmospheres . . .

WALKER REFRACTORIES

and petrochemical application

H-W LOW-IRON LIGHTWEIGHT CASTABLE 22

(Former brand name—H-W 56 Low-Iron Lightweight Castable)

Manufactured from low-iron lightweight aggregates and high purity calcium-aluminate binders, it is especially designed for oil refinery units operating in hydrogen and other reducing atmospheres.

H-W EXTRA STRENGTH LIGHTWEIGHT CASTABLE

(Former brand name—H-W 85 Lightweight Castable)

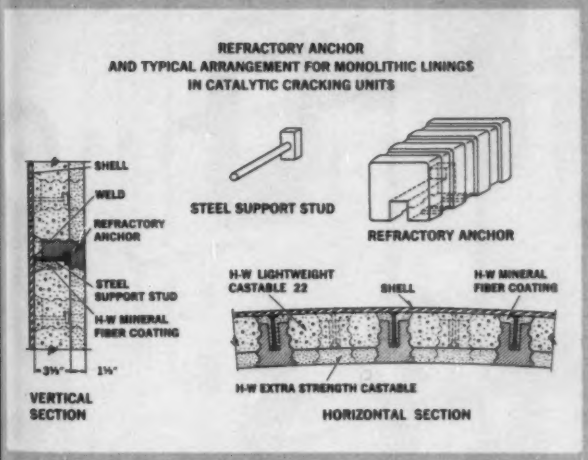
Consisting of carefully selected and sized lightweight aggregates and hydraulic setting binders, it has combined properties of light weight, high strength, low heat conductivity and desirable refractoriness. It is used for lining ducts and breechings, boiler wall backing and tube decks, furnace walls, roofs and doors.

H-W CC LIGHTWEIGHT CASTABLE

This combination of best selected and sized lightweight aggregates and hydraulic setting binders was especially developed for "one-shot" linings in catalytic cracking units.

IMPROVED ANCHORING METHOD

Supplementary to the conventional anchoring methods, the design of the refractory anchor installation shown here is particularly suitable for certain specific uses such as regenerators and reactor linings.



H-W REFRACTORY BRICK AND SHAPES

All classes of fireclay brick, high-alumina brick, silica brick, basic brick and acid-proof brick and tile are available for petroleum and petrochemical needs.

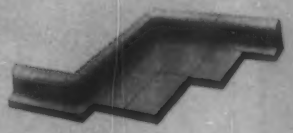
ALAMO AND VARNON

These brands possess chemical and physical properties which make them especially suited for the diversified operating conditions of refinery and petrochemical processes. Enhanced by high temperature heat treatment, VARNON has a high degree of immunity to damaging effects of carbon monoxide and hydrocarbon gases at critical temperatures.

A Typical Duro Tower Packing Ring
Ring No. 403 6" x 6"

H-W MULLITE—KORUNDAL—H-W CORUNDUM

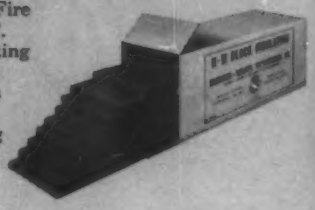
These high-alumina refractories are noted for unusual stability under severe temperature conditions, and excellent resistance to fluxing by corrosive slags and fumes, such as volatile alkalies and vanadium oxide present in the ash of some oils.



Duro Acid-proof Floor Tile

H-W INSULATING REFRACTORIES

All Classes of Insulating Fire Brick—1600°F. to 3000°F.
Mortars for Laying Insulating Brick
H-W Lightweight Castables
H-W Block Insulation
H-W Mineral Fiber Coating
H-W Finishing Cement



New Brochure

describes complete line of refractories for petroleum refining and petrochemical applications including all classes of castables, brick and shapes, insulating firebrick, block insulation, mineral-fiber coating, finishing cement, and bonding mortars.

Send today for your personal copy

Harbison-Walker Refractories Company
Farmers Bank Building, Pittsburgh 22, Pennsylvania

☐ Please send me a copy of your new brochure, *Harbison-Walker Refractories for the Petroleum Refining and Petrochemical Industries.*

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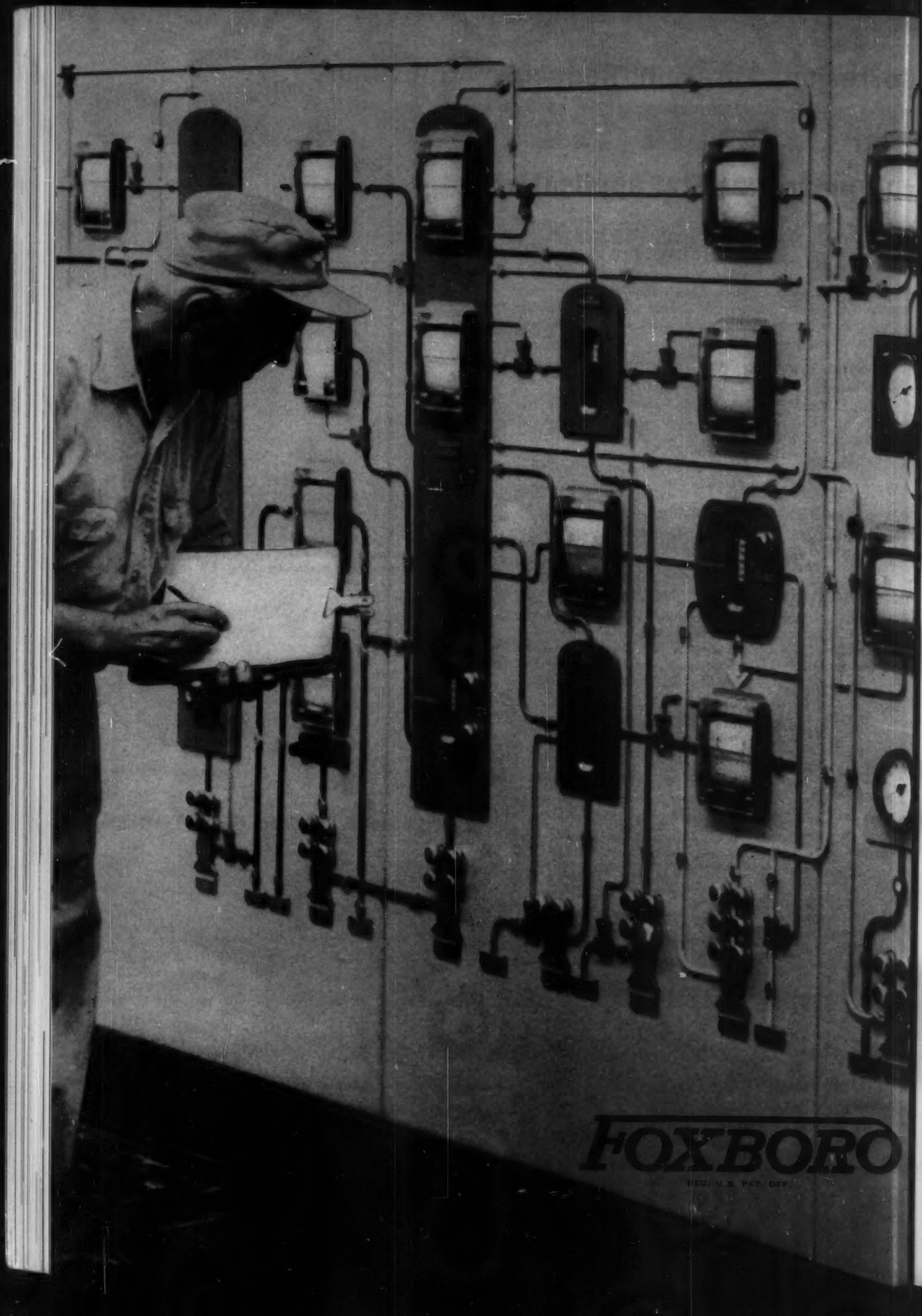
COMPANY_____

TITLE_____

ADDRESS_____



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Oil me
equipme
Get the
before
Bulletin
Foxboro

*Reg. U. S.

CO

Sun Oil Company reports:

"TWO YEARS OPERATION— AND WE HAVEN'T HAD A CONSOTROL* OFF THE PANEL YET"

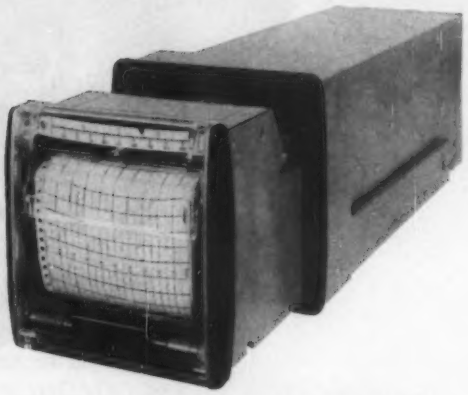
Not only by their unvarying dependability of control, but also through unusual economy of maintenance, Foxboro pneumatic Consotrol Recording Control Stations have proved a profitable investment for Sun Oil Company at Marcus Hook, Penna.

Over two years ago, 129 pneumatic Consotrol instruments were installed as complete instrumentation for the control rooms of the ammonia plant and the Houdriflow catalytic cracking unit in this modern Sun Oil refinery. In continuous operation ever since, not a single Consotrol Recorder or Controller has yet needed recalibration or realignment!

Add to this the fact that Consotrol Recorders need replacement of their full-scale, 4-inch strip charts as infrequently as once a month — re-inking only twice a year — and it's easy to understand why Sun Oil men at Marcus Hook are more than satisfied with Consotrol equipment.

Get the full story of these ultra-dependable Recording-Controllers before you design your next control system. Write for Consotrol Bulletin 13-18. **The Foxboro Company, 7411 Neponset Avenue, Foxboro, Massachusetts.**

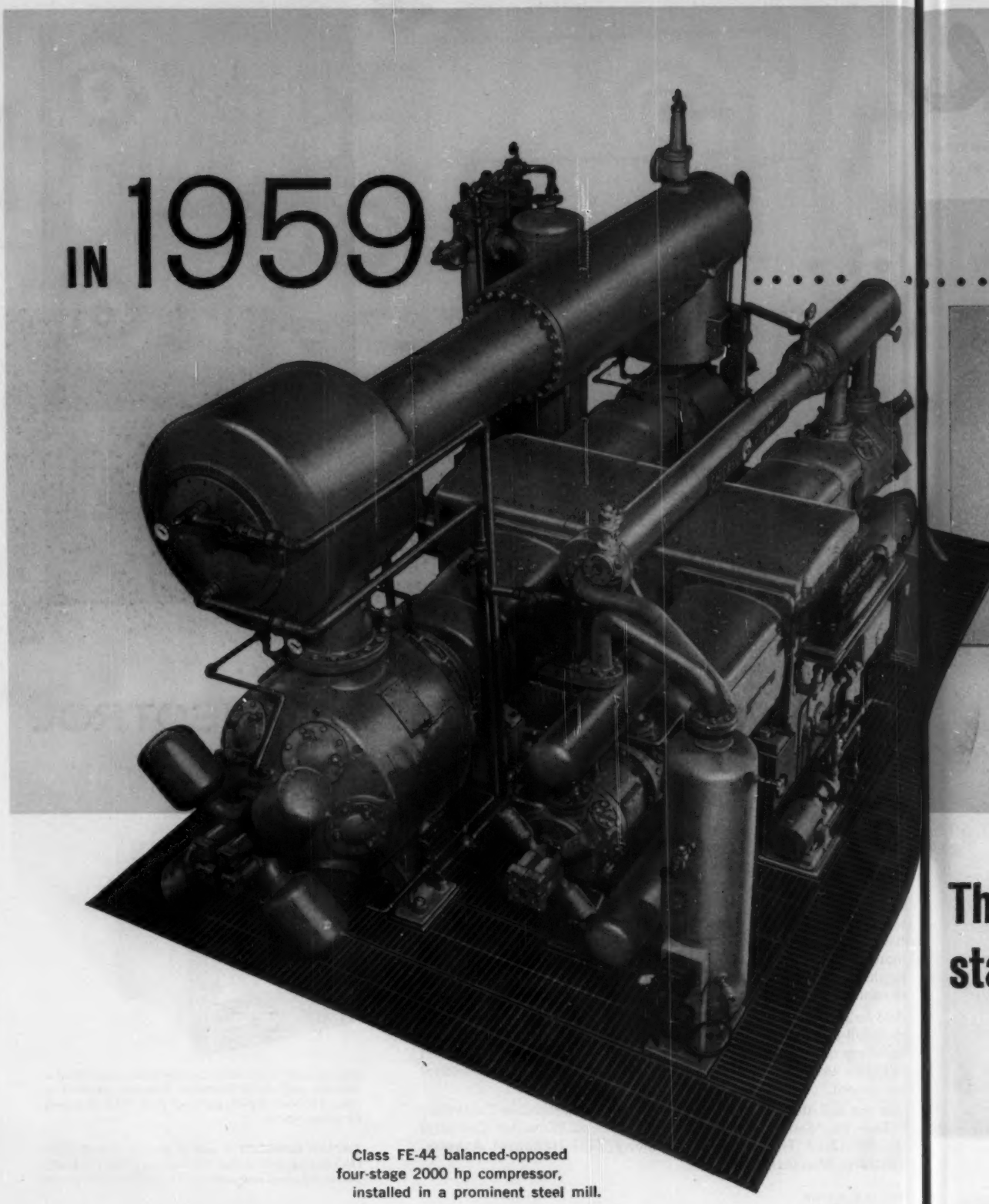
*Reg. U. S. Pat. Off.



Each pneumatic Consotrol Control Station consists of a Recorder with M/58 Controller integrally mounted at rear. Complete station pulls out from front of panel, as shown above.

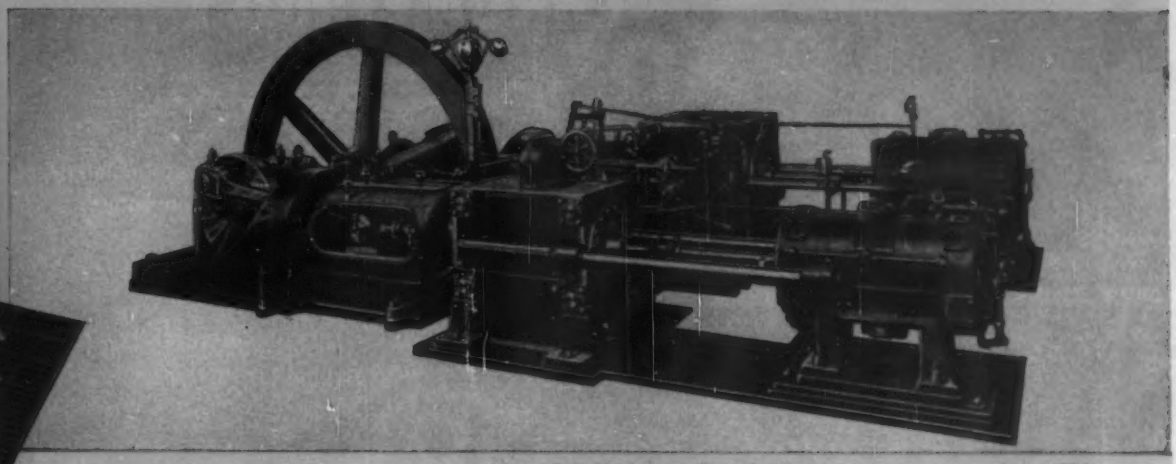
SHOWN OPPOSITE is part of graphic control panel for cracking unit at Sun Oil Company, Marcus Hook, Penna. All panel instruments were supplied by Foxboro.

CONSOTROL INSTRUMENTS



Class FE-44 balanced-opposed
four-stage 2000 hp compressor,
installed in a prominent steel mill.

AS IN 1902



"Franklin" CP Compressor, Corliss engine driven, as built in 1902.

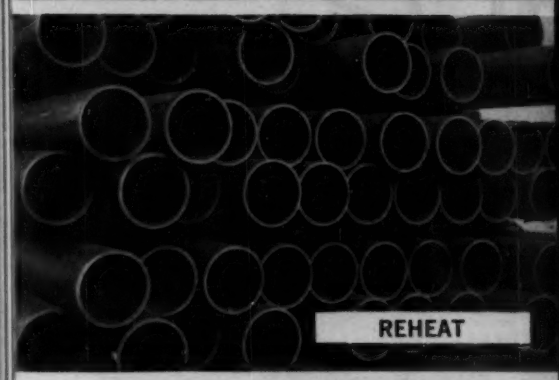
The CP name on an Air Compressor stands for UNEXCELLED PERFORMANCE

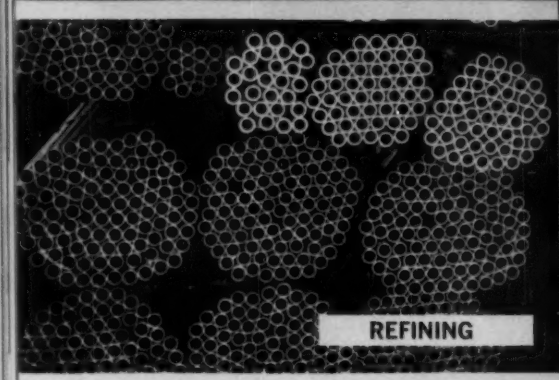
Maintaining a good reputation requires constant improvement of the product. For more than half a century "CHICAGO PNEUMATIC" has meant unexcelled compressor performance.

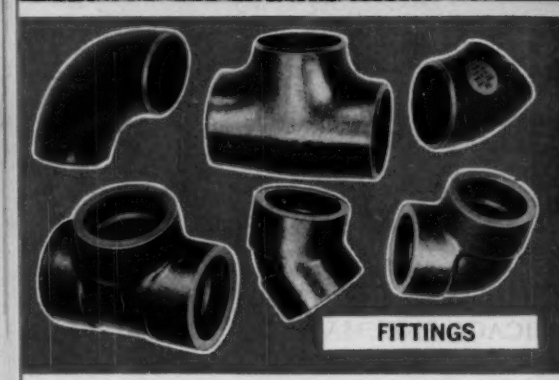
CP Compressors are built in sizes to 5000 hp for pressures up to 15,000 psig, or for vacuum service. Motor or steam drive. Lubricated or non-lubricated cylinders.

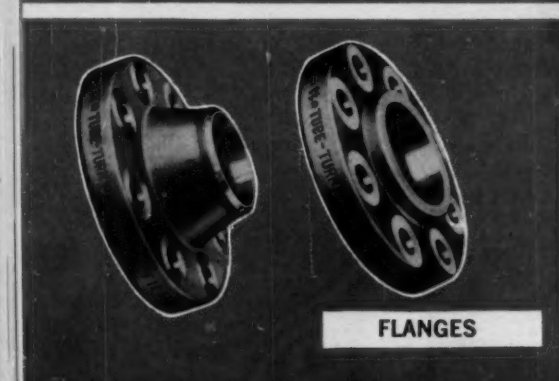
Chicago Pneumatic 8 East 44th Street, New York 17, N. Y.

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS









Capitol

PIPE

1275 SU
LO. 3-

CHROME MOLY
...from Capitol

Shown at left are some of the many specia Alloy products carried in inventory.

MAIN STEAM: 8⅝" O.D. through 14" O.D. heavy wall 1¼% and 2¼% chrome. Also the complete range Schedule 160 and Double Extra Heavy Walls ½" ips t 8" ips.

REHEAT: 10¾" O.D. through 20" O.D. in all schedule num bers Seamless 1¼% chrome . . . plus Standard and Extr Heavy Walls in all sizes.

REFINING: ¼" ips through 14" O.D. Seamless 4/6% chrome. Special tube sizes, large O.D. and higher chrom analysis also stocked.

FITTINGS AND FLANGES: Seamless Alloy Welding Fittin are carried in inventory to match Standard and Extra Heav sizes shown above. Forged fittings and flanges are ava able for quick delivery.

CAPITOL PIPE
WORLD-WIDE

IN PHIL
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HICAGO
terprise 60

PIPE & STEEL PRODUCTS INC.

1275 SUBURBAN STATION BUILDING • 1617 PENNSYLVANIA BLVD.
LO. 3-5817 • PHILADELPHIA 3, PENNSYLVANIA

Serving...

Capitol is able to serve all piping phases of the power and refining industries with an **Inventory Program** based on years of experience in the high temperature—high pressure Chrome Alloy Field. Products of U.S.A. "Top Brand" manufacturers are your assurance of highest quality.

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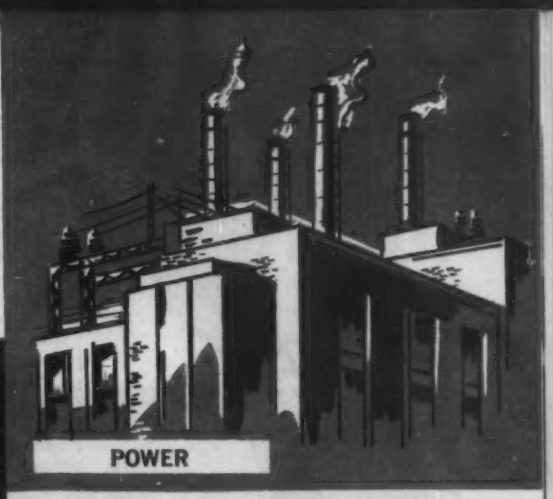

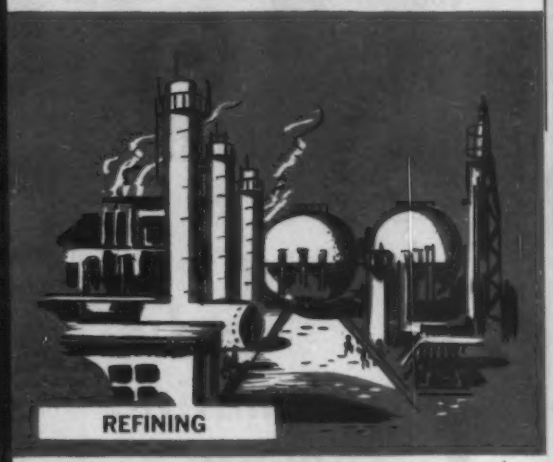

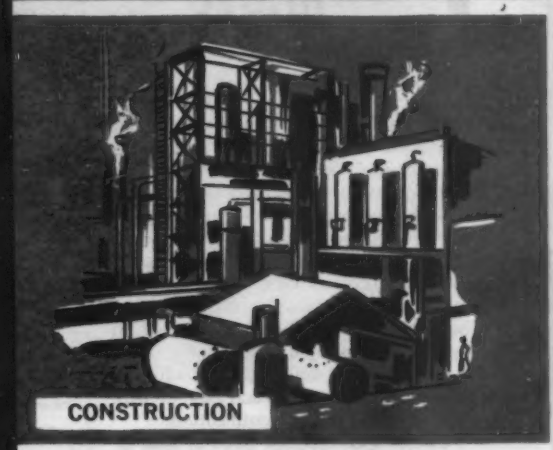

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Hit the Spot!

This is not a letter in the form readers have come to expect on this page, but because of its interest and because it shows the dollars-and-cents value of a recent PETROLEUM REFINER presentation, we use this excerpt from a "Trip Report" by one of our editors:

"Ed Scheibel, director of Engineering, York Process Equipment Corporation, West Orange, N.J., said he is very happy with the presentation of his manuscript, 'Figure Multicomponent Extraction' in our September issue.

"With Dr. Scheibel was a fellow from American Cyanimid Co. He said his company was faced with an extraction problem. That night when he got home he saw Scheibel's article in PETROLEUM REFINER and it really hit the spot."

Data Questioned

To The Editor:

I found your recent article (Louis P. Karvelas and Dale O. Cooper's "These Factors Affect Rate of Return," July, 1959, PR) very interesting. I am certainly in agreement with you that investment rate of return cannot be the only guide in making investment decisions. Risk is certainly a factor to be considered.

Unless I misunderstand the situation, I believe you have made a serious error in the analysis you present in Table 3. You state in note (a) that, "The $1,000 needed as investment in the third year for Project A, in the combined case, could come from the regeneration of the $1,000 at the termination of Project B after two years."

If the $1,000 invested in Project B were funds used as working capital which could actually be recovered tax free at the end of the project, then the after tax cash flow pattern to be evaluated must be stated, instead of as you show it in Table 3.

YEAR	Investment	After Tax Receipts
At 0	$1000	.....
During 1	.....	$ 551
During 2	.....	551
End 2	.....	1000

If this is not the case and the $1,000 is actually invested in facilities and cannot be recovered intact, then the cash flow you show in Table 3 is incorrect and should be shown as follows:

YEAR	Combined Project Investment	After Tax Receipts
At 0	$9000	.....
During 1	.....	$1051
During 2	.....	1551
Start of 3	1000	.....
During 3	.....	2000
During 4	.....	2500
During 5	.....	3000
During 6	.....	2500
During 7	.....	2000
During 8	.....	2000
During 9	.....	2000
During 10	.....	2000

It would be approximately correct to merely reduce the cash receipts in either the second or third year by the $1,000 which must be re-invested. You "can't eat your cake and count it too." If you re-invest it reduces profit. There is absolutely no difference between a capital investment and an expensed cost except for the difference in income tax impact. This is a difference in *timing*, rather than a difference in amount.

In view of the foregoing, it is my opinion that one of the rates of return you have calculated (either Project B or the combined project) is incorrect and also that your conclusion that the rate of return of the combined project is greater than the parts is also in error.

R. I. Reul, Coordinator
Industrial Engineering Dept.
Food Machinery and Chemical Corp.
New York

Author's Comment

We find that we are in error, as you pointed out with regard to Table 3. The point we were trying to make is that a low return, short range project may be eliminated because it is below some minimum rate of return *even during a period of idle capital.* This project, if accepted, could enhance the total return for a company by substituting a positive return rather than the zero return of idle capital. However, the duration of this project should be short for it is only justified in an idle capital period. A company with a sound investment policy will not maintain long periods of idle capital for this is too costly. This idea was discussed in our article under effect of capital availability.

To demonstrate this, Table 3 should have been as follows:

	Project A		Project B		Project A & B	
	Inv.	Inc.	Inv.	Inc.	Inv.	Inc.
0	9000	....	1000	....	9000	....
1	....	500	....	551	....	551
2	....	1000	....	551	....	1051
3	....	2000	....	....	....	2000
4	....	2500	....	....	....	2500
5	....	3000	....	....	....	3000
6	....	2500	....	....	....	2500
7	....	2000	....	....	....	2000
8	....	2000	....	....	....	2000
9	....	2000	....	....	....	2000
10	....	2000	....	....	....	2000
Int. Rate of Return	....	14.95	....	6.7	....	15.15

To illustrate the idle capital position, the total investment in Project A is shown as of the beginning of the first year, even though $1,000 of it would not be needed till the beginning of the third year.

—REMEMBER—

Comment on topics of timely interest to those in the processing industry are always welcome. Address, Editor, PETROLEUM REFINER, Box 2608, Houston 1, Texas.

Petroleum Refiner

'59 PETROCHEMICAL HANDBOOK

SEEING IS SAVING...

One important advantage of plant models is that management can fully exercise their judgment and experience in approving design and layout *before* construction starts.

Here, SunOlin Chemical Company vice-president S. S. Johnson and president James I. Harper are shown reviewing, with Kellogg project manager Robert Jacks, details of their new 200 ton/day urea plant—now being built by Kellogg, using the Fauser-Montecatini Process.

For SunOlin, as for many Kellogg clients, scale models have proved to be an unequalled communications tool for management . . . a superior design tool for engineers . . . a modern construction tool for field workers . . . a sure way, in every way, to minimize man-hours and materials.

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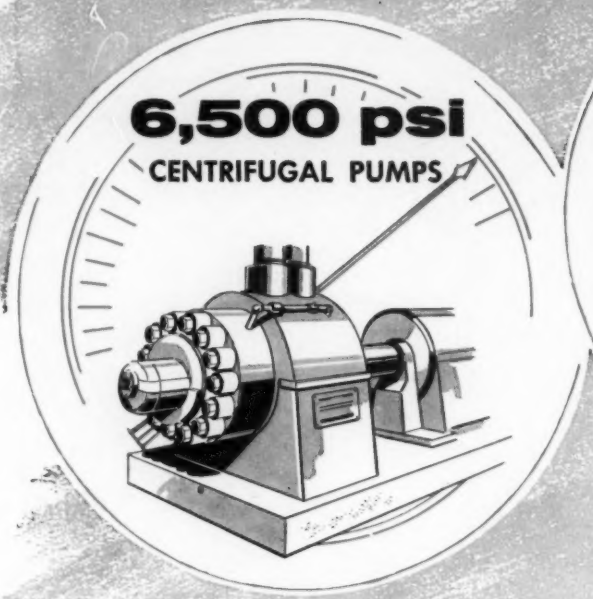

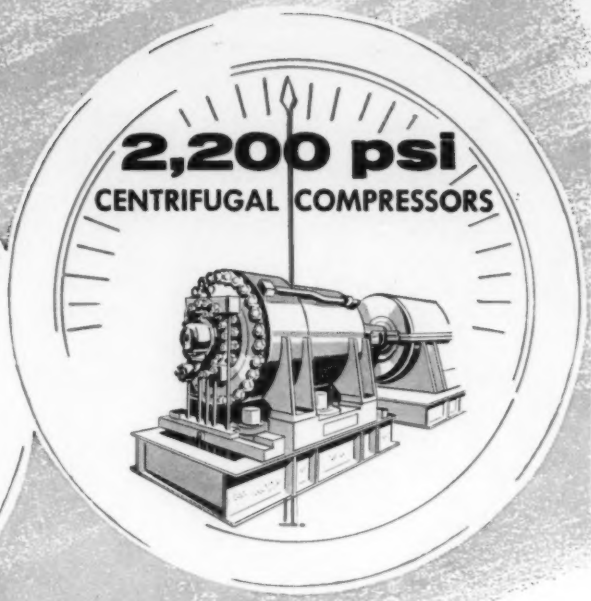

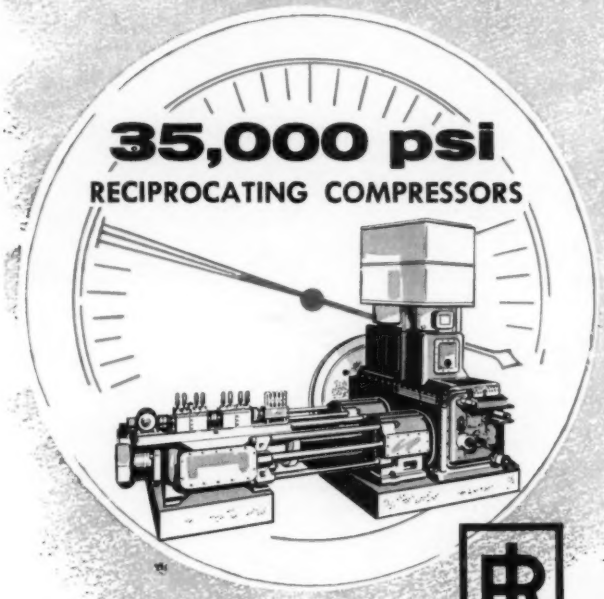

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OUR INDUSTRIAL ADVISORS for the 1959 Petrochemical Handbook are shown above, left to right: Herman C. Schutt, H. C. Schutt & Co.; Tom Ponder, Petrochemicals Editor; R. L. Geddes, Stone & Webster Engineering Corp.; Charles M. Blair, Bakelite Company; Francis E. Reese, Monsanto Chemical Company; and John T. Barr, Escambia Chemical Corporation. These experts pointed out important developments and guided us in our search for material included in this issue.*

FOREWORD

Petrochemical Handbook

IN SPITE OF THREE very real and pressing problems, the petrochemical industry still is showing remarkable growth and staying power. Production for 1959 will show a 15.5 percent increase over 1958. This means production of about 49 billion pounds, valued at more than $6 billion.

The three problems facing the petrochemical industry are:

Overcapacity: Many of the best known petrochemicals show more production capacity available than sales can cover for several years ahead. However, this is not all dark, as growth rates have a habit of changing suddenly and unexpectedly. Even at the present rate of growth, most of this excess capacity will be wiped out before 1963. Overcapacity also means greater selling effort and higher quality to meet competition.

Shrinking Profits: Petrochemicals continue to hold the line on prices. In fact, over-all prices for petrochemicals have dropped 5 percent while the cost of living has increased 11 percent. Labor, raw materials and equipment costs have risen as well. Possible solutions to this problem will lie in larger and more efficient plants but also, perhaps even more important, will be the development of new processes for old, existing petrochemicals. Sharing equally in research budgets with new petrochemicals will be development of improved processes to help hold the line on present petrochemicals.

Foreign Competition: U.S. export market has been seriously curtailed. First by expansion of existing plants overseas and new construction where petrochemical plants never existed. This, coupled with common markets, has effectively cut off many of the normal routes of exports. However, U.S. companies are building foreign plants and entering into joint ventures to build foreign sales. Because of the increasing rise in the standard of living overseas, foreign plants will not be able to keep pace and some export market will always exist. Also, the South American market will need to be covered more intensively.

The future of petrochemicals still is very bright. Population growth, new uses and applications and further replacement of standard materials will account for much of petrochemicals' future growth. By 1965, the demand for petrochemicals will grow to 85 billion pounds with a value in excess of $10 billion. The increasing expenditure for research, both applied and basic, will lead to expansion of uses for present products and entirely new resins, fibers, synthetic fuels and synthetic lubricants.

Thomas C. Ponder
PETROCHEMICALS EDITOR

*The attendance by executives, engineers, superintendents or other employes of petrochmical companies at these conferences does not constitute an endorsement of PETROLEUM REFINER over any other publication. The fact that men of outstanding ability are allowed to attend these planning conferences shows the interest which companies have in sound editorial content for the benefit of the industry.

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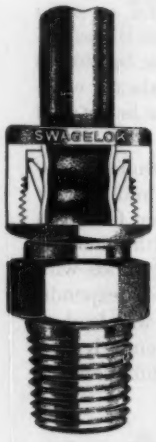

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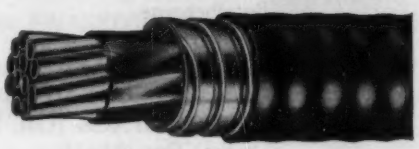
CONSTRUCTIONS

TYPE VA

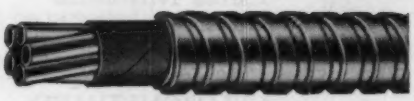
For Impact and Corrosion Resistance. Core tubes with vinyl sheath covered with Moore-Loc modified-square-lock construction armor with cord packing.

TYPE VAV



For Impact and Maximum Corrosion Resistance. Same construction as Type VA (*above*) but with outer vinyl sheath. 24-gauge galvanized steel armor gives maximum pull-apart and impact resistance.

TYPE A



For Impact Resistance in Dry Locations. Core tubes are wrapped in vinyl-impregnated insulating tape. Tape insulates and cushions core tubes inside metal armor.

TYPE AV

For Corrosion and Impact Resistance. Same construction as Type A (*above*) but with outer vinyl sheath. All four constructions available with metal or plastic core tubes.

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Petrochemicals—Still Growing Fast

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Robert L. Bateman
Union Carbide Chemicals Company, New York

PETROCHEMICALS continue their phenomenal growth which has provided the stimulus to the expansion of the chemical industry in the postwar period. First, in the late 1940s, the aliphatic segment was in the lead with many new plants and expansions to existing plants in the Gulf Coast area for synthetic alcohols, esters, acids, glycols, oxides and monomers. There followed in the early 1950s a five-year period of rapid expansion for the inorganic petrochemicals—ammonia, sulphur, and carbon black. Now, more recently, the aromatics—benzene, toluene and xylene—have moved into the limelight with large expansions of plant facilities.

Production. Preliminary estimates for 1959 point to another all-time high. Production of petrochemicals should total 48.8 billion pounds—an increase of 15.5 percent over 1958 (Table 1). The upsurge in the over-all economy, which began in mid-1958, is apparent in the production figures for the entire chemical industry. These will show a gain of 14.5 percent for 1959 over 1958 (174 billion pounds vs 152 billion). Since the strong demand is benefiting all segments of the chemical industry, the petrochemical share of the total remains unchanged at 28 percent, the same as 1958.

Valve. The value of petrochemicals produced in 1959 will increase 17.5 percent to $6 billion (Table 1). This is equivalent to 57.5 percent of the production value of all chemicals. It is now apparent that the petrochemical share of the over-all industry is gaining very slowly. A large tonnage of inorganic chemicals is required in the synthesis and upgrading of petrochemical olefins—and, therefore, the increase in petrochemical production brings with it a concurrent expansion for many basic inorganic chemicals. The construction expenditures estimate, released by the Manufacturing Chemists' Association in March 1959, emphasizes this inter-relationship. For the period 1958-1960 MCA estimates an expenditure of $1.04 billion for general organic and petrochemical facilities and an expenditure of $800 million for general inorganic facilities.

Surplus capacity is not a serious problem to the petrochemical industry in 1959. Nevertheless, some surplus plant still exists for those petrochemicals that were operating at the lowest rates in 1958. In this category are methanol, ammonia, ethylene oxide, vinyl chloride and styrene. Based upon the presently authorized expansions, it appears that other products may come into an oversupply position in the near future. In many cases, this situation will occur from increasing participation of processes that, in the past, were based predominantly on non-petrochemical raw materials. The projected expansions for maleic and phthalic anhydrides, for fumaric acid, for vinyl acetate, and for acrylonitrile should prevent any shortage of these chemicals in the next three to five years.

Research Grows. Underlying the continued growth of the petrochemical industry are the heavy expenditures for research. During the 1950s expenditures by the organic chemical industry have almost tripled from $115 million in 1950 to an estimated $315 million in 1958 according to Tariff Commission reports. The results of this expanding research effort are evident in two ways. Entirely new chemical products are brought to market for development of uses. Examples include the peracetic acid process and the numerous epoxy compounds derived therefrom, for use in resins now being developed by Union Carbide. The high molecular weight polyethylene oxide water-soluble resins offered by Union Carbide are just beginning to find markets in the textile, mineral and packaging fields. The new polyformaldehyde resin recently announced by duPont gives promise of opening additional new fields largely untapped by petrochemicals. This resin is claimed to possess properties comparable in many respects to such metals as zinc, steel, brass, and aluminum.

New Processes. Possibly the greater emphasis of research has been directed to the development of new and

U.S. Petrochemical Production (Excluding Crudes)
(Shown In Billions Of Pounds)

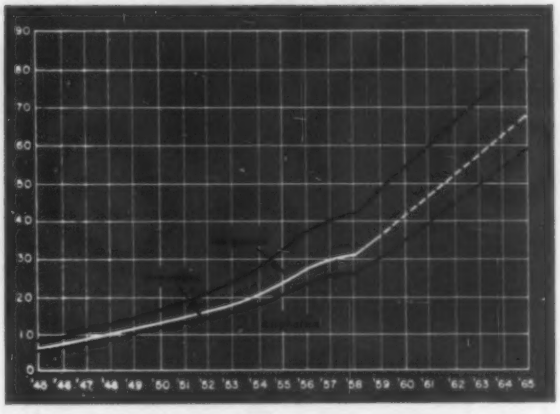

FIGURE 1—While aliphatics continue to dominate U.S. petrochemical production, notice how inorganics help maintain accelerated growth into 1965.

TABLE 1—U.S. Petrochemicals Production—1959 vs. 1958.

IN BILLIONS OF LBS.

	1957	1958	Percent Change 1957-58	Est. 1959	Percent Change 1958-59
Petrochemicals:					
Aliphatics	25.9	26.4	1.5	30.1	14.0
Aromatics	3.7	4.5	21.5	5.7	26.5
Inorganics	10.7	11.3	6.0	13.0	14.5
All Petrochemicals	40.3	42.2	4.5	48.8	15.5
All Chemicals	149.0	152.0	2.0	174.0	14.5
Petros. as Percent of All Chemicals	26.8	27.7	.....	28.0	.....

IN BILLIONS OF DOLLARS

Petrochemicals:					
Aliphatics	$3.89	$3.95	15.5	$4.51	14.0
Aromatics	0.63	0.76	20.5	0.97	27.5
Inorganics	0.41	0.41	.....	0.53	29.0
All Petrochemicals	$4.93	$5.12	4.0	$6.01	17.5
All Chemicals	$8.79	$9.19	4.5	$10.40	13.0

improved processes for older petrochemicals. Shell Chemical is commercializing a new process for acetone with concurrent production of hydrogen peroxide, which will be employed in a new glycerine synthesis starting with acrolein. Standard Oil of Ohio in expanding their petrochemicals operations have announced a new, more direct synthesis of acrylonitrile from propylene and ammonia. Celanese have developed, commercially, the process for acrylic esters from propiolactone. Escambia Chemical is planning production of methacrylate esters, by a new process starting with isobutylene. Continental Oil looks forward to developing a new synthesis for higher aliphatic alcohols from ethylene. These alcohols are intended for detergent applications to replace similar alcohols obtained from vegetable oils.

New Plants. With the over-all economy moving ahead at a fast rate, construction expenditures for plant facilities are expected to continue to expand in the last half of 1959 and during 1960. There are no available figures for the petrochemical industry alone, due to its complexity. The Securities & Exchange Commission does compile statistics for the over-all chemical industry. The previous peak year was 1957 with construction expenditures of $1.7 billion. These declined to $1.3 billion in 1958. The decline continued into early 1959 but turned upward in the second quarter. For the full year expenditures are now estimated at $1.4 billion. The authorizations for new plants and expansions in existing ones are likely to continue to increase so that 1960 should see a new peak above the $1.7 billion established in 1957.

Plastics continue to be the most spectacular and dynamic outlet for petrochemical raw materials and will receive a large portion of the new construction money. Polyethylene, in 1959, will become the first billion pound plastic and there is no indication that its meteoric growth is slackening. Polypropylene is now available in commercial quantities from several producers and will add its unique properties to the expanding applications for synthetics. Other plastics whose properties and broad utilization indicate bright prospects for the future include the polyurethane resins. These are synthesized from polyethers or polyesters made from aliphatic raw materials, and the aryl isocyanates which has toluene as the starting raw material. The greater use of synthetic resins in the building industry is looked for in the coming decade. Growth in this area will contribute materially to continued expansion of the petrochemical industry.

By 1965, the demand for petrochemicals will grow to 85 billion pounds with a value in excess of $10 billion. The increasing expenditures for research, both basic and application in nature, will lead to expansion of uses for present products and entirely new resins, fibres and synthetic fuel and lubricants.

About the Author

Dr. Robert L. Bateman, a frequent contributor to technical journals, is director of product development for Union Carbide Chemicals Co., New York. He received his M.S. degree in 1933, and his Ph.D. degree in 1935, both from University of Pennsylvania. In 1935 he was an Industrial Fellow, Organic Synthesis Fellowship at Mellon Institute, and in 1937, he joined the Fine Chemicals Division of Union Carbide Chemicals Co. In 1944 he was made manager of that department, and in 1954 was promoted to his present position.

Synthetic Detergents

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THE SYNTHETIC DETERGENT picture continues in the same direction it has taken for the last few years; syndet sales increased while those of soap decreased. Detailed figures for the change are shown in Table 1. Total soap sales went down 3 percent, as compared with the first half of 1958; total syndet sales went up 8 percent. Syndets now have about 75 percent of the combined syndet-soap market, as compared with about 72 percent a year ago.

The striking part of the report is the big advance in the sales of liquid syndets. These are mostly for home use—the light-duty for dishwashing, the heavy-duty for the automatic clothes washers. A big increase in sales of heavy-duty liquid syndets corresponds to the increase in sales of automatic washers. Although soap sales fell off tonnagewise, actual dollar volume did not. This reflects lower sales of low-cost laundry soaps, but increased sales of the more expensive bar soaps.

TABLE 1—Sales—First Half of 1959*

	Pounds (Thousands)	Percent Change from 1st Half, 1958	Dollars (Thousands)	Percent Change from 1st Half, 1958
Solid Soaps	508,124	— 3.0	150,430	+ 4.6
Solid Syndets	1,273,122	+ 3.9	275,529	+ 0.7
Liquid Soaps	13,960	— 2.1	2,716	+ 0.2
Liquid Syndets	267,480	+32.2	97,467	+29.4
Total Soaps	522,084	— 3.0	153,146	+ 4.5
Total Syndets	1,540,602	+ 7.9	372,996	+ 6.9

* American Soap and Glycerine Producers Association.

Anionics. The biggest selling syndet is still sodium dodecyl benzene sulfonate. Although benzene remains stable in price at 31 cents a gallon—from either coke-oven or petroleum sources—dodecyl benzene has gone down from 12 to 11 cents a pound. Before the steel strike, benzene from petroleum had reached nearly 50 percent of the total production, as compared with 35 percent a year or so ago. This suggests that oil companies are in a position to increase benzene production if the situation justifies it.

Although dodecyl benzene sulfonate as the potassium salt has been used as the syndet in liquid detergents, other syndets are more soluble and, therefore, more suitable if they can compete on an economic basis. Fatty alcohols made by building up petroleum-derived ethylene with the aid of aluminum as a catalyst, have reached the pilot-plant stage. These are easily sulfated to give readily soluble products of good detergent power.

A German process replaces the conventional chrome catalyst with another of undisclosed composition. Then by hydrogenolysis at high pressures, the product is unsaturated alcohols for sulfation. The alcohol ether sulfates also have good properties for formulating liquid detergents. One of the newer compounds offered for this purpose is disulfonated dodecyldiphenyloxide.

New detergents in Holland from petroleum, use as raw material heavy recycle oil obtained in the fractionation of catalytically cracked hydrocarbon oils, also the residual oil from such fractionation. The oil is solvent extracted to remove aromatic components. The paraffinic hydrocarbon mixture left is cracked in the vapor phase to produce a mixture of higher alkenes. These alkenes serve as the basis for making *sec*-alkyl sulfates by sulfation and neutralization. Up to 50 percent of the alkenes may remain unconverted; this unconverted material is used for production of alkylarenesulfonates by alkylation of benzene containing C_{10}-C_{14} alkenes. This in turn is sulfonated and neutralized to give a good detergent when compounded with a high proportion of builders.

New oil-soluble surfactants continue to appear, mostly used as lubricant additives. A new surfactant which serves as an emulsifier for vinyl acetate and acrylic esters is made by reacting acrylic acid, its alkyl ester, and sulfur dioxide with an organic peroxy compound.

Nonionics continue to increase and actually are encroaching on the realm of dodecylbenzene sulfonates. This is because low-cost nonionics are being made which offer greater chemical stability than the sulfonates and so have applications where the latter would not be suitable. An example is the condensation of tall oil with a number of moles of ethylene oxide as long practiced to give an inexpensive detergent. A modification of this which increases the cost somewhat is to reduce the tall oil to the corresponding alcohols, and condense these with ethylene oxide. This gives an ether of high stability.

Synthetic alcohols which may in turn be condensed with ethylene oxide to give a nonionic, are formed by

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Dr. Snell's wife, **Dr. Cornelia Tyler Snell,** is technical literature searcher with the Snell consulting firm. Holder of a B.S. degree from Syracuse University, and M.A. and Ph.D. degrees from Columbia University, she has experience in synthetic detergents, detergency, water conditioning, high school teaching, pediatric research, research chemistry, and as assistant chemist at a major university. An ACS member, Dr. Snell has been president and chairman of the society's New York Section.

the oxo reaction. An olefin is treated with carbon monoxide and hydrogen to give an aldehyde which is easily oxidized to the alcohol. Condensation of a number of moles of ethylene oxide with an ether alcohol is said to give products comparable in detergent properties to that of a nonylphenol-ethylene oxide condensate. It may be seen that ethylene oxide is still one of the important raw materials in making nonionics.

Ampholytics. These are relative newcomers to the surfactant field. They behave like cations in acid solution and like anions in alkaline solution, and so may have special uses in strongly acid or alkaline media. A series of such commercial products are salts of N-alkyl *B*-aminopropionates. A basic formula is $RCH(NH_2)COOH$. These products are reported to inhibit corrosion at low concentration levels.

Syndets continue to grow in volume. Research in the field is active, resulting in new products, new formulations, and new applications.

Pesticides

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DESPITE THE CUTBACK in domestic agricultural acreage and the serious declining effect of foreign competition on the production of some domestic pesticidal materials, the consumption of petrochemicals in the agricultural pesticide field continues to increase.

The field of pesticides (insecticides, fungicides, and herbicides) has been a relative newcomer as an outlet for petrochemicals since the modern pesticide field as we know it has only had its major start in the last decade.

Table 1 shows the U.S. production of major pesticidal chemicals by calendar years for 1956, 1957, and 1958. It is estimated that the actual production in 1959 will increase in the case of the "all-inclusive basket compounds from aldrin to toxaphene," and will decline in the case of benzene hexachloride, calcium arsenate, copper naphthanate and copper sulfate. However, substantial increases are contemplated in 2, 4-D herbicide formulations, DDT, methyl parathion and ethyl parathion, as well as 2,4,5-T acid. On the other hand, methyl parathion and ethyl parathion will be affected to a great extent by the influences of foreign materials. However, even with the major decline in the price situation on both methyl and ethyl parathion, it is felt that domestic production will go back up to 1956 levels since foreign materials coming into the United States should decline.

The effect of foreign competition in the field of the organic phosphorus insecticides is pointed out in Table 2 which shows the actual imports of these materials

U.S. Production And Exports Of DDT
(Shown In Millions Of Pounds)

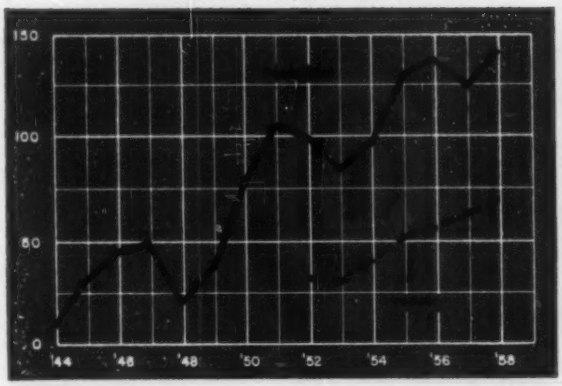

TABLE 1—U. S. Production of Some Major Pesticidal Chemicals by Calendar Years, 1956-1958.

CHEMICAL	1956 1,000 Lb.	1957 1,000 Lb.	1958[1] 1,000 Lb.
Aldrin, chlordane, dieldrin, endrin, heptachlor, and toxaphene (combined production)	86,659	75,424	98,280
Benzene hexachloride (gross)[2]	84,599	39,559[4]	31,000
Benzene hexachloride (gama equivalent)[2]	14,700	7,300[4]	6,200
Calcium arsenate	27,106	19,478[4]	9,000
Copper naphthenate	2,012	2,130	[5]
Copper sulfate	133,616	141,360	97,192
2,4-D acid	28,835	34,251[4]	28,500
2,4-D acid esters	19,476	24,137)	
2,4-D acid salts[3]	1,766	3,182)	22,827
DDT	137,659	124,545[4]	143,216
Disodium methylarsonate	[6]	618	[5]
Lead arsenate	11,756	11,920[4]	[5]
Methyl bromide	10,204	9,653	[5]
Methyl parathion	[6]	1,925	[5]
Nabam	5,486	4,961	[5]
Parathion ("ethyl parathion")	6,529	5,962	[5]
Pentachlorophenol	31,385	28,346	[5]
Phenyl mercuric acetate	693	570	[5]
Sodium chlorate	110,136	118,284	134,498
2,4,5-T acid	5,169	5,334[4]	3,500
2,4,5-T acid esters	7,045	6,831	[5]
Ziram	1,436	1,277	[5]

[1] Preliminary.
[2] 1958 includes lindane; 1956 and 1957 without lindane.
[3] Sodium and amine salts.
[4] Revised figure.
[5] Figure not yet available.
[6] Figure not publishable because it would disclose individual operations.

Sources: U.S. Tariff Commission; U.S. Bureau of the Census; U.S. Bureau of Mines; chemical industry.

TABLE 2—Imports of Organic Phosphorus Insecticides

COMPOUND	1954 (Pounds)	1955 (Pounds)	1956 (Pounds)	1957 (Pounds)
Parathion	60,000	292,000	150,000	760,000
Methyl parathion	.....	.....	150,000	1,503,961
Guthion	.....	.....	34,804	274,590
Schradan	.....	.....	.....	3,381
Chlorthion	5,020	2,000	1,000	.....
Bayer 21/99	.....	.....	265	3,633
Totals	66,020	294,000	336,069	2,545,565

Source: Chemical Division, U.S. Tariff Commission, "Imports of Coal-Tar Products."

which originate, for the most part, from Denmark and Germany. However, in 1958, domestic producers met the foreign prices and in 1960, it is expected that foreign materials will cease being imported into the States. However, there will be the continuing effect on the market for domestically-produced materials in the Latin American, South American, and European markets which have normally been supplied by the U.S. Exportation of these materials is virtually non-existent at this time.

Table 3 shows U.S. production and exports of DDT. This basic insecticidal raw material has continued its upward swing in production, and the increase in exports since 1952 represents the start of the malarial program sponsored by the United Nations International Childrens Emergency Fund as well as the International Cooperation Administration of the U.S. government and its predecessors in foreign aid.

The current anti-malarial program is destined to continue through 1962 and it is expected that both the production and the exports of DDT will increase correspondingly. The other anti-malarial insecticide, Dieldrin, has run into some significant problems of resistance overseas, and because of its higher cost, is not finding the original popularity that was expected of it in the initial stages of the anti-malarial program.

The production and sale of agricultural pesticides in 1958-59 continues to be affected to a great extent by federal regulations which require many more stringent toxicological and residue data to be available before newer products are permitted to be sold. As a result, introduction of these new products has been curtailed. It is the fear of many of the authorities in the industry that these regulations will have the effect of slowing down the introduction of many new products which are required to maintain the ever-constant struggle against resistant insects and may affect the industry in the next decade. It is estimated that a new product which is introduced from the very inception stage to pilot plant prior to commercial production and distribution, requires the expenditure of a million dollars. This makes the development of newer products quite a management risk.

However, the distribution pattern was marked by the elimination of unreasonable and uneconomical trade factors, and the realization that upgrading of raw materials into the technical chemicals and subsequent upgrading to the formulations, must be profitable or management would look with a great deal of skepticism at this industry. This has resulted in a more reasonable, a more profitable and a more logical approach to the marketing of products. On the other hand, the last two years has seen the development of specialized products and distribution through specialized channels, with the national distributors throwing the burden of distribution on the localized state-wide and region-wide distributors. Because of the varying requirements and great local influences in the use of these various materials, this type of distribution is far more logical than distribution on a national level which marked the initial stages of the modern pesticide industry as we know it today.

About the Author

Melvin Goldberg received his A.B. degree from Johns Hopkins University in 1935, and his M.S. degree from Georgetown University in 1940. Following graduation from Georgetown, he joined the Insecticide & Fungicide Unit of the War Production Board where he remained until 1945. In 1948 he founded and now owns Pesticide Advisory Service. From 1950 to 1952 he served as a consultant to the U.S. Department of Agriculture.

Synthetic Fibers

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THE TOTAL PRODUCTION of non-cellulosic fibers, exclusive of textile glass fibers, was slowed somewhat by the recent recession in textiles, but has now resumed its vigorous trend upward. Total U.S. production[1] in 1957 was 515 million pounds, up 115 million over 1956; in 1958 there was a slight drop to 490 million pounds. At the present rate, 1959 production should exceed 600 million pounds. A continuation of this vigorous trend is predicted.

Beginning with three million pounds of nylon sold in 1940, the growth of the non-cellulosic fibers is all the more spectacular because the total consumption of all fibers has remained relatively constant during this period (between 6-7 billion pounds). The explanation of this success lies in several factors:

1. The trend to lighter weight, more durable, easily-cared-for fabrics;

2. Uniformity of product accompanied by low waste; and

3. Stability of price with a favorable downward trend.

The vigorous growth of the non-cellulosics will be strengthened by the development of more functional, higher performance, lower cost fibers, either by improvement of existing types or by the introduction of new fibers. Special comment is warranted on individual types comprising this fast growing, petroleum-based market.

Nylon has been the backbone of the non-cellulosic fiber industry, growing from 2.6 million pounds in 1940 to 293 million pounds in 1958, over a hundredfold increase. There are large potential markets yet available that remain to be developed. The recent development of yarn texturizing processes, putting two-or-three dimensional crimp in filament yarn, has given nylon new covering power in fabrics and new pleasing touch and appearance. It has made it possible to use continuous filament nylon in areas heretofore limited to staple fibers, thus opening a large new market.

In the industrial field, there is much potential in tire cord, cordage, and coated fabrics or reinforced films. So far, nylon has captured a substantial amount (40 percent) of the passenger car replacement tire market and a high percentage of off-the-road and truck tire market, but has not yet broken into original equipment on passenger cars. Nylon was recently adopted by the Navy to replace completely manila hawsers and lines on all ships. It may even be successful in replacing heavy anchor chain.

Acrylic and vinyl fibers containing acrylonitrile have risen from almost one million pounds in 1950 to 97 million pounds in 1958, one hundredfold increase in eight years. Because of their warm touch and resilience, these fibers have been successful largely as replacements for wool. Their versatile properties have made them successful in a variety of end uses, such as sweaters, blankets, carpets, jersey goods, and in blends with wool, cotton, and rayon. The hydrophobic nature of these fibers results in fabrics of improved wrinkle resistance and dimensional stability to washing. The biggest potential market is in the broadwoven field and in carpets.

Polyester fibers have grown rapidly from 5 million pounds in 1953 to 53 million pounds in 1958. This success has been due largely to their extremely good resilience under dry or wet conditions. These properties contribute greatly to dimensional stability in fabrics, for so-called wash-and-wear purposes. Primary usage is as staple, blended with wool, cotton, or rayon. Fabrics containing major quantities of polyester fiber have outstanding crease retention and wrinkle resistance properties, making them ideal for ease of care use. In addition, they are quick-drying. When the price is made more competitive with other fibers, the market may expand more rapidly.

Polyolefins. High density polyethylene fibers have just emerged in the last two years and polypropylene fibers are just now appearing. These are mostly extruded monofilaments for heavy deniers, suitable for seat covers, upholstery, screens, ropes, etc. Finer textile deniers are still under development. There are problems of insufficient dimensional and sunlight stability, dyeability, and low melting point to be improved or contended with, limiting immediate application in general textile use. The market is expected to develop slowly for these fibers as some of these problems are gradually overcome. However, potential low cost is favorable to growth. Higher melting members of the polyolefin series will develop even more slowly, either because the element of low cost is not immediately apparent or because the technology of these fibers is not sufficiently advanced.

Other fibers being produced in lesser quantities than polyesters or acrylics are copolymers of vinyl chloride and vinylidene chloride, and vinylidene cyanide. The chlorine-containing fibers have the advantage over the olefin fibers of non-flammability (although they melt readily), but the disadvantage of higher density. The olefin fibers will provide tough competition.

Another fiber to watch is based on polyvinyl alcohol, now manufactured in Japan and Germany and under consideration in this country. High strength fibers can be made having comfort properties similar to rayon and cotton. Wrinkle resistance properties, especially at high humidities, will require improvement.

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[1] Textile Organon, May, 1959, p. 76.

About the Author

Dr. D. W. Chaney is executive director of research for The Chemstrand Corp., Decatur, Ala., where he heads all research on synthetic fibers. His work includes new products, product and process improvement and long-range basic research. Previously, Dr. Chaney had been assistant director of research, 1953-58, and senior group leader, 1952-53. With Chemstrand eight years, he had formerly been with American Viscose Corp. since 1942. He has a B.A. degree from Swarthmore College and M.S. and Ph.D. degrees from the University of Pennsylvania.

Plastics

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IT IS PREDICTED that the plastics industry will continue to grow at a rate more than twice as fast as the rate for all industrial production for at least the next seven years. The main reasons for optimism in the growth of plastics consumption are:

- Plastics are becoming an increasingly better value to the consumer as the prices of wood, metal, ceramics, paper and glass continue to rise. Plastics have remained constant or tended downward in price, and thus, they have improved their competitive position.
- Plastics fabrication techniques are better understood and better engineered than ever before. Very large, low operational cost fabrication capacities are available today to utilize plastic raw materials.
- The consumer has given unqualified acceptance to plastics in a wider range of end uses than ever, and this has broadened the base of the plastics market.

Polyethylene, including low, medium and high density grades, is the sales leader in the plastics industry. It will become, with vinyl plastics, a billion pound plastic this year.

The major uses of polyethylene are expected to be

for film, injection molding, wire insulation, extrusion coatings, and blow molding. Polyethylene film, for example, is finding ever increasing application in packaging, as moisture-vapor barriers in construction, and as an economical mulch for plants on the farm. There are literally hundreds of other uses for polyethylene, a majority of which require different compounds. The status of any one compound for a specific use is precarious due to the continuous development programs of resin producers for improving the performance of their product over that of competitors. The troublesome result of this dynamic replacement and obsolescence of products—if steps are not taken to minimize it—is that the resin manufacturing business tends to become a "made-to-order" or "job shop" operation rather than a "commodity of commerce" type business of producing materials for inventory and selling from inventory.

Low density polyethylene has had the most spectacular growth of any large volume plastic until high density polyethylene came along. Several factors, unprecedented in the plastics industry, accelerated the growth of high density polyethylene at an early stage in the development of its market. The simultaneous construction of new production facilities by many companies resulted in a serious imbalance between total supply and demand before the product gained acceptance among consumers. Although any one expansion probably could have been justified by a realistic market forecast of demand, the repeated duplication of supply facilities has proved unfortunate in terms of excessive idle capacity. However, many of the essentials for rapid growth were present including the support of extensive and costly development programs to find new uses for the resin. The tremendous pressure from excessive supplies is believed to have accounted for promotional programs not known to other new plastics. Probably the strongest driving force of all, resulting from excessive imbalance in supply and demand, was that of price. No other plastic has been sold at so low a price so early in its commercial growth.

Vinyls. It can still be said that the vinyls are the most versatile of any plastics yet developed. They will be one of the two charter members of the billion pound per year plastics club in 1959. Vinyls are used for coating beer cans, molding phonograph records, extruding electrical insulation on wire, calendering film for rainwear and sheeting for upholstery, for plastisols in slush molding, for making foam for furniture cushions, or formulating water-based paints.

There are over 20 polyvinyl chloride producers and over 60 polyvinyl acetate resin producers. Production capacity exceeds demand and price trends have been downward during the past five years. However, new applications, the expansion of old applications, and the inherent diversity of vinyls will keep them growing, although at a slower rate. The most significant growth areas are estimated to be in latex coatings, flooring, wire coating, slush, dip and rotational molding of dispersion-type resins and record molding.

Polystyrene. Polystyrene-type plastics include a variety of materials such as straight polymers, copolymers and rubber modified materials. They are used primarily for molding, extrusion, and surface coatings. Their relatively low cost and economical fabricating techniques are probably the most significant features in stimulating their growth.

Polystyrene plastics had a phenomenally rapid growth from 1948 to 1954 amounting to a 19.6 percent compound growth rate per year. Leveling off from this steep curve has taken place for the period 1954-1958 when the rate was reduced to 12.2 percent. A compounded growth rate for the next seven years is estimated at 4 percent a year.

Phenolics. Confidence in the future of phenolics, the first "workhorse" of the plastics industry, is evidenced by its forecasted yearly growth rate of 3 percent compounded annually.

Phenolics have served well for almost 50 years and will continue to do so in applications where dimensional stability, resistance to heat, and good electrical properties are essential. The largest pound growths are expected to be in such markets as plywood adhesives, bonding of fibers for thermal insulation, foundry resins, and decorative and industrial laminates.

Urea and Melamine. The consumption of melamine and urea is expected to expand at a compounded rate of 5.3 percent annually over the next seven years. Molding plywood, adhesives, laminates, surface coatings, and the treatment of paper, textiles and leather should continue to account for the major increased use of urea and melamine resins.

Cellulosics. A 3 percent rate of growth is predicted for cellulosics. This is less than the forecast for industrial production as a whole. Nevertheless, growth is envisioned for cellulosics—one of the oldest classifications of resin within the plastics industry. The excellent toughness and clarity of the cellulosics are two important properties that will keep this product in the marketplace. Cellulosics are used in a wide variety of applications including such things as steering wheels, dials and handles for automotive use, shoe heels, telephone hand sets, and pen and pencil barrels. The chief deterrent to faster growth is believed to be high cost for this plastic.

Coumarone-Indene and Petroleum Resins. Coumarone-indene and petroleum resins are low-price polymers which are frequently obtained as secondary materials in the coke and petroleum refining industries. The principal use of these products is in the manufacture of so-called asphalt floor tile. Coumarone-indene and petroleum resins were first made to upgrade floor tile made from asphalt. The upgrading material proved so good it soon replaced asphalt in about 90 percent of this market. The success of coumarone-indene and petroleum resins runs parallel to the rapid growth of "asphalt" tile during the past 10 to 12 years. An estimated yearly compounded growth rate of 3.9 percent is predicted for these materials.

Polyesters. The polyester category is estimated to grow in the next seven years at a rate of 10.1 percent compounded annually. This is a small growth, however, as compared to the potential consumption in the applications for which these plastics are promoted. If the proper material and the required low-cost fabrication techniques are developed, reinforced plastics consumed by

the construction and maintenance industry alone could make it a billion pound per year class of plastic.

Small Volume Plastics and New Products. Some of the plastics in this category in 1958 were acrylic resins, nylon, epoxies, silicones, fluorocarbons and polypropylene. Among the new products that will be listed in the future are polyformaldehyde, polycarbonates and scores of unnamed products. The predicted compounded growth rate for these old and new plastics, over a seven-year period, is estimated at about 25 percent per year.

About the Author

A. F. Sward has a chemical engineering degree from the University of Minnesota. In 1935 he joined Union Carbide Chemicals Co., and in 1940 moved to Union Carbide Plastics Co. He was appointed manager of the Calendering, Molding and Extrusion Divisions in 1946 and in 1952 was named sales manager of the Consumer Products Department. Sward was appointed general sales manager of bonding and laminating in 1956 and in late 1957 was chosen manager of the Market Research Department of Union Carbide Plastics. He is a member of ACS and the American Association for the Advancement of Science.

Aromatic Hydrocarbons

L. G. Parkinson
Amoco Chemicals Corporation
Chicago

THE CHEMICAL INDUSTRY consumed about half of the 811 million gallons of benzene, toluene, and xylene produced from all sources in 1958. The petroleum refiner extracted about 525 million gallons of BTX from an estimated reforming capacity of 5 billion gallons. Most of this capacity is used to make a mixed aromatic stream to boost gasoline octane rating.

Benzene. Virtually all of the benzene produced today is used as a chemical intermediate. Total benzene consumed in 1958 was about 358 million gallons, of which almost 60 percent was consumed in the manufacture of styrene and phenol. The remainder was used in dodecylbenzene, nylon, insecticides, aniline, chlorobenzenes, maleic anhydride, and some minor uses.

Benzene consumption is expected to grow at the rate of 5-7 percent annually for the next few years. Despite the brisk business in benzene during the past months, domestic capacity is still more than adequate for present demand. Total domestic benzene capacity is difficult to measure accurately. Coke oven benzene is dependent upon steel mill operation and rated capacity is realized only when the steel industry is running at 100 percent capacity. Petroleum benzene capacity is limited to the available extraction capacity which is a fraction of the total reforming capacity.

Imported benzene totaled 44½ million gallons in 1958 compared to 55 million gallons in 1957. Because the European chemical industry has increased its benzene consumption, we expect less European material to be imported into the United States. The trend toward lower imports is expected to continue for several years.

Toluene production in 1958 was about 240 million gallons according to U.S. Tariff Commission reports. The largest use for toluene as a solvent is in lacquers for wood and automotive finishes. Wood furniture finishes required 10 million gallons in 1958. About 11 million gallons were used in 1958 in automotive lacquers made from nitrocellulose, cellulose acetate or acrylics. There is a strong possibility that water-based coatings will be used to a greater degree by the automotive industry. However, development of formulas will take time and this trend is not expected to affect toluene usage appreciably in the next few years.

The major uses for toluene as a chemical raw material include: diisocyanates, vinyl toluene, benzyl chloride, toluene sulfonates, benzoic acid derivatives, and various nitrated and halogenated toluenes.

Petroleum toluene is in long supply at present and for the foreseeable future. To the petroleum refiner, this represents no particular problem for he can utilize any excess in gasoline. To the chemicals manufacturer, the petroleum industry represents a dependable source of quality toluene.

Total toluene demand is expected to remain at the present level for several years. The dominant use of toluene is in aviation gasoline.

Xylene production in 1958 was approximately 200 million gallons. It was used primarily in making motor fuels, aviation gasoline, solvents, and chemical intermediates.

About the Author

Laurel G. Parkinson is general manager of marketing and a director of Amoco Chemicals Corp., Chicago. He joined the company early in 1958 as general sales manager, chemicals, coming from Lever Brothers Co., New York. There he had been manager of the Industrial Chemicals Department since 1954. He has also held positions in sales, manufacturing, research and development at Atlas Powder Co. In 1937 Parkinson graduated from Kent State University with a B.S. degree in chemistry. He also attended Ohio State and Temple universities.

Xylene as a chemical appears to have a bright future. Petroleum xylene streams vary in composition but generally contain about 15 percent ethyl benzene, 20 percent *ortho*-xylene, 20 percent *para*-xylene, and 45 percent *meta*-xylene. The *ortho*-, *meta*-, and *para*-isomers can be oxidized to the corresponding dibasic acids (phthalic, isophthalic and terephthalic), which, in turn, find their way into alkyd resins, polyesters, films, fibers, plasticizers, dyes and pharmaceuticals. Ethyl benzene is currently being separated from the xylene stream for the production of styrene monomer.

Demand for *para*-xylene will show the greatest increase due to the rapid growth of polyester films and fibers. The use of *ortho*-xylene has been confined to the production of phthalic anhydride. Demand for *meta*-xylene is contingent upon future development of isophthalic acid as a competitor of phthalic anhydride.

Summary. Because of his need to produce high octane gasolines, the petroleum refiner maintains tremendous reforming capacity and will continue to supply an increasing portion of the total available aromatic hydrocarbons. BTX capacity will be adequate to meet demand for some years to come. The chemical industry's use of BTX aromatics will continue to grow at a modest rate. So long as the octane race continues, the chemical industry will consume only a small percentage of the total aromatics produced through catalytic reforming.

Olefins

C. H. Thomas
Enjay Company, Inc.
New York

ANY DISCUSSION of the olefiins is a discussion of the building blocks of the petrochemical industry, therefore as the petrochemical industry goes so goes the olefins.

Ethylene ranks first in importance to the petrochemical industry. The first stage of the ethylene market growth rocket was fueled by synthetic ethyl alcohol. Now that synthetic alcohol has captured the lion's share of the ethyl alcohol market, new outlets have stepped in to boost this growth along its way.

Ethyl alcohol is now second in importance to ethylene oxide, which has been growing steadily for the production of ethylene glycol. More recently its growth has been increasing rapidly in the surfactant field where it is used to produce non-ionic surfactants. It is interesting to note that non-ionic surfactants which are produced from ethylene oxide account for almost 25 percent of all the synthetic surfactants produced in the United States this year. It appears that this rapid growth will continue for some time in the future.

Miscellaneous products of ethylene oxide such as higher glycols, glycol ethers, and ethanolamines which have many diverse end-uses will continue a substantial but not spectacular growth. Ethanolamines, due to their use in detergents will undoubtedly lead the group.

The third stage of the ethylene rocket is powered by polyethylene. This highly versatile plastic material will undoubtedly become the first billion pound per year plastic this year. New polymerization techniques have made it possible to produce a wide range of polyethylenes which have opened new markets not heretofore available to plastics. This growth should continue at its present rapid pace until polyethylene becomes second only to ethylene oxide in importance as an outlet for ethylene.

These three uses, ethylene oxide, polyethylene and synthetic ethanol, account for 75 percent of the ethylene consumed. All of the other outlets such as styrene and halogenated ethylene are growing at about the same modest rate as ethanol.

Propylene is also proving to be a highly versatile raw material. Like ethylene, its initial start in the petrochemical industry was in the production of its corresponding alcohol by hydration. Similarly, this outlet for propylene has leveled off and new outlets are now pacing propylene expansion. The largest share of the synthetic detergents industry is based to some extent upon propylene chemistry. This industry has been increasing very rapidly as synthetic detergents have taken over a larger and larger share of the market previously held by soap. Tetrapropylene or its higher homologs will continue to dominate the sodium dodecyl benzene sulfonate market as the basic raw material for the alkylation of benzene to produce alkyl aryl sulfonates.

Non-ionic detergents, which it has been shown are contributing to the steady growth of ethylene, are also important to propylene. These materials are based principally on nonyl phenol and tridecyl alcohol. Both of these raw materials are produced from low-molecular weight propylene polymers. Thus, as this segment of the detergent field continues to expand its share of the market, propylene can be expected to expand at least as rapidly. In fact, since nonyl phenol has been expanding at the expense of octyl phenol, propylene will undoubtedly expand a little more rapidly than the total nonionic market.

Much has been written recently about the excellent

About the Author

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strength, stiffness, clarity, gloss and processability of polypropylene for such uses as film and sheeting, molding and synthetic fibers. At least five plants are in production or will be in production of polypropylene very shortly. Several other companies are believed to be very close to announcing their intention of producing this material. Two or three are companies who have announced intentions of producing linear or high-density polyethylene and are considering alteration of their plants to produce polypropylene. This will provide the impetus for a more rapid growth in propylene than has been experienced in the past.

Butylene. A great deal of research is going on in the field of co-polymers. The wide variation in properties which can be accomplished with these co-polymers make this a very desirable route to obtain the better properties of different types of polymers in one compound. We look for this to revitalize the market for normal butylenes as co-polymers with ethylene and propylene. One manufacturer is already in commercial production of ethylene-butylene co-polymers.

The all butyl tire has become a commercial reality. Its superior riding qualities and aging properties have created a demand which will, over the next several years, contribute heavily to a considerable increase in the rate of growth of the isobutylene market.

The increased use of antioxidants in foods, packaging, feed supplements, rubber and plastics has contributed to a steady increase in isobutylene consumption. This will continue unabated for several years.

Butadiene and Isoprene. At present butadiene consumption follows the trends of the automotive industry since the largest share is used in the production of styrene-butadiene rubber for tires. Other uses such as dibasic acids for resins, plasticizers, synthetic lubes, etc. will add slow but steady growth to butadiene consumption.

A bright spot in the butadiene picture lies in the recent development of *cis*-polybutadiene. This "synthetic natural" rubber when added to natural rubber, imparts superior properties which cannot be obtained from either natural or synthetic rubber. At least two companies will soon be in production of this new polymer.

Isoprene markets have been quite small over the years. As a constituent in butyl rubber this market will enjoy some growth along with the expansion of the all butyl tire market.

Polyisoprene, another "synthetic-natural" rubber, has been developed. Increased demands for natural rubber and the resultant higher prices will help these new synthetics find their place in the rubber market. This will create a demand for isoprene which will more than likely require an expansion in the current isoprene capacity.

Fluorochemicals

J. P. Farrell
General Chemical Division
Allied Chemical Corporation
New York

THE FIELD OF FLUOROCHEMICALS, which has exhibited steady expansion over recent years, today shows a somewhat confused growth picture as a result of technological developments during the past 18 months or so.

In the petroleum industry itself, there are trends that might well indicate both increases and decreases in the use of hydrofluoric acid—the production barometer of the fluorochemical field. On one hand, the number of hydrofluoric acid alkylation plants has increased 50 percent since 1955, from 20 plants then to 30 last year. On the other, the mushrooming trend toward air travel by kerosine-burning jets among both civilians and the military augurs ill for consumption and production of aviation gasoline, and, correspondingly, alkylate and HF.

Today there are 10 HF plants in this country which produce for consumer and captive uses. The newest is the Nitro, West Virginia, plant of Allied Chemical's General Chemical Division, which went on stream early this year.

The HF production picture shows an output of 113,000 tons in 1958, down from the 135,000 tons in 1957 and the record 139,000 tons in 1956.

The major factor in the downturn is the decline in aluminum production. The aluminum industry maintains its own captive HF plants. Last year, with output off 7 percent, the aluminum industry absorbed 25 percent of the country's hydrofluoric acid production. Merchant HF production of 84,000 tons in 1958 was off 2,000 tons from 1957, but up 6,000 tons from 1956.

A broad view of the fluorochemicals market takes HF as its point of departure. The "minus" side of the ledger comes largely from the passive role of hydrofluoric acid

About the Author

James P. Farrell is a vice president of Allied Chemical Corp.'s General Chemical Division. Previously director of sales for two years, he currently heads General Chemical's sales program. Farrell has been with the company 24 years, serving successively as sales manager for heavy chemicals, assistant manager of the Chicago office, manager of St. Louis Office, and assistant manager of sales, New York. He is a graduate of LaSalle College with a B.S. degree in business administration.

in supplying the needs of its dependent industries. The "plus" side of the picture can be seen as a function of HF's active role in stimulating industry to provide more materials for fluorochemical refrigerants, aerosol propellants, plastics and others.

In recent years fluorinated hydrocarbons have been produced in increasing quantities to meet the needs of thriving aerosol and refrigeration industries. Public acceptance of push-button sprayers, as well as of air conditioners, home freezers and modern refrigerators, has boosted the market. For example, aerosol sales have climbed from 3,500,000 units in 1946 to some 470,000,000 units in 1958.

However, there are indications that the growth rate may be slower than anticipated due to use of alternate propellants which have recently come into the picture. Hydrocarbons, such as mixtures of isobutane and propane, have replaced fluorocarbons for many applications which formerly consumed large tonnages.

For example, it is estimated that 66 percent of aerosol shave creams (whose sales totaled more than 60,000,000 units in 1958) are now propelled by these alternate gases. At the same time, the over-all growth of the aerosol industry continues unabated. Projections for 1963 indicate a market of one billion units.

The demand for fluorinated hydrocarbons is being filled by four major chemical manufacturers: Allied Chemical's General Chemical Division, E. I. du Pont de Nemours & Company, Pennsalt Chemicals Corporation, and Union Carbide & Carbon Corporation.

While production volume of these gases is now more than triple what it was in 1950, the four manufacturers have geared their capacity to more than meet the anticipated demand for the foreseeable future. It is believed that by 1965, 35 percent of the country's hydrofluoric acid output will be directed to this area. In order to meet this expected growth, the 1965 production of carbon tetrachloride (a major raw material for these gases) will probably top the 235,000 ton mark.

New fluorochemicals are yet another expansion factor. Fluorinated plastics are now very much on the scene and are becoming increasingly available. In the petroleum industry, for example, they are being used as gaskets because of their many unusual properties. They retain flexibility over a wide temperature range, are relatively impermeable to gases, have zero moisture absorption and are inert, non-flammable and non-corrosive. These properties plus the transparency of some types also make the plastics ideal packaging materials where maximum product protection is required.

Other new product uses are as fire extinguishers and as solvents for degreasing metal, plastic, elastomer and paint or varnish surfaces with little or no solvent action on the base material. The use of fluorinated hydrocarbons as blowing agents for polyurethane and other foams marks a new and expanding field of application.

Thus, the fluorochemical field is in a state of flux. Its growth is a certainty, yet is probably less dynamic than was previously the case.

Synthetic Rubber

J. D. D'Ianni
The Goodyear Tire and Rubber Company, Akron, Ohio

AFTER A PERIOD of consolidation in 1958, the synthetic rubber industry has come bouncing back in 1959. This segment of the petrochemical industry has now resumed its spectacular growth and will continue to use substantial amounts of petroleum-derived raw materials, such as butadiene, styrene, chloroprene, isobutylene, acrylonitrile, isoprene, and other monomers.

U.S. consumption of all rubbers in 1959 should hit a new high of 1.6 million tons, an increase of 17 percent over 1958. Of this total, about 65.5 percent will be synthetic, mostly SBR (Styrene-Butadiene rubber), but including substantial amounts of neoprene, butyl, nitrile rubbers, polyurethanes, silicones, etc. In 1958, 64.5 percent of the total rubber consumed was synthetic.

The production of SBR in this country has rebounded to a very high level. It appears likely that output of this one type will exceed 1 million long tons this year, an all time high, compared to last year's figure of 872,602 long tons. Output has been stimulated by a large export demand, which amounted to 194,000 long tons (all types synthetic rubbers) in 1958. As for future export demand, the production capacity of synthetic rubber plants in operation and being built outside the United States will narrow the gap between supply and demand in that market, and these will eventually result in a reduction in export requirements from this country.

Intensive research and development work on synthetic rubber has resulted in an astonishing proliferation of new polymers, each of which will undoubtedly find an appropriate place in the markets of the future. One has only to mention a few to illustrate the situation—*cis*-polyisoprene, *cis*-polybutadiene, ethylene/propylene copolymers, vinylpyridine rubbers, fluoro rubbers, "ADDUCT" rubbers, polyurethanes, fluoro- and nitrile-containing silicone rubbers, and polyacrylics.

Synthetic "natural" rubbers are rapidly approaching the commercial stage as work continues by Firestone, Goodrich-Gulf, Goodyear, and Shell. A closely related development is *cis*-1,4-polybutadiene as exemplified by Phillips Petroleum, Firestone, and similar polymers by Goodyear and other producers. Shell is producing 5 tons per day of Isoprene Rubber, and has started construction of a plant at Torrance, Calif., with a capacity of 20,000 long tons per year. Firestone will build at Orange, Texas, a unit capable of producing 30,000 long tons per

year of isoprene and polybutadiene rubbers. Phillips Petroleum has been offering pilot plant quantities of polybutadiene rubber and is rushing plans for a 20,000 long tons per year plant at Borger, Texas. Others, such as Goodyear and Goodrich, are continuing extensive pilot plant studies in anticipation of the construction of commercial units in the near future. With natural rubber selling at more than 37 cents per pound, the time seems appropriate for the commercialization of its synthetic counterpart.

Much work is being done to develop an economical method for production of isoprene monomer, since polyisoprene would otherwise be unable to compete with natural rubber in the long run. Several methods based on readily available petroleum raw materials are under study and should result in the commercial availability of isoprene at a price equal to or less than that of butadiene.

Present butadiene producers, with excess producing capacity, will welcome the development of a new rubber, *cis*-1,4-polybutadiene, based entirely on butadiene, but should be cautioned that its production may tend to reduce the production of SBR.

Cis-1,4-polybutadiene is not a direct replacement for natural rubber, but in tire stocks its unusual combination of properties, such as excellent resistance to abrasion, low heat build-up, and good low-temperature properties, indicates it will be a good extender of natural rubber and an economical replacement for some of the current SBR requirements.

Another new development difficult to assess is that of rubbery copolymers made from ethylene and propylene with stereospecific catalysts, such as those developed by Montecatini. Potentially, these have great importance because of the relatively low cost of the monomers, but may require special handling in a rubber factory.

Butyl rubber has received a new lease on life as evidenced by announcement of the availability of an all butyl passenger car tire. Butyl consumption dropped sharply in 1954-56 when the tubeless tire was widely adopted for new automobiles but it has gradually enlarged its market in recent years. It will be of interest to observe the reaction of the public to the claims for this tire, such as quieter, smoother ride.

Work on other "quiet ride" tires is underway by the major tire manufacturers.

The battle between latex and polyurethane foams continues at an accelerated rate. Latex foam has been helped by the development of synthetic latices capable of making 100 percent synthetic products, while polyurethanes have been aided by lower material costs. In 1958 the rubber consumed in latex foam amounted to 141 million pounds, whereas flexible polyurethane foam for all applications is estimated by the market at 25-28 million pounds including scrap. An unusual application, a tire filled with polyurethane foam, was suggested by one tire manufacturer with the claimed advantage of freedom from punctures.

Research on elastomers continues to grow, as evidenced by the new laboratory facilities recently put into operation by du Pont, International Latex Corporation, U. S. Rubber, and others doing research in this area.

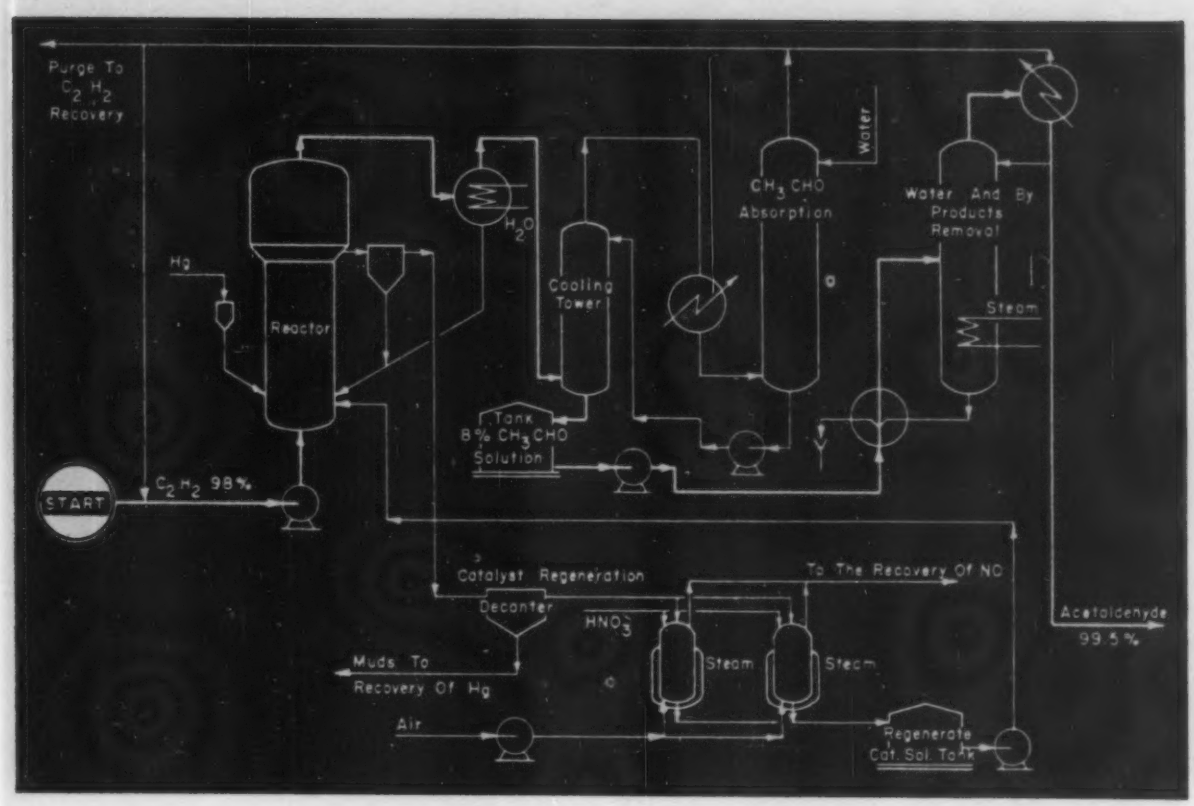
New rubbers are constantly being developed to meet the demands of the space age and to anticipate the special requirements forecast by our military forces. Elastomers for high temperature requirements will be needed and may develop from research underway with aluminum, phosphorous, and boron compounds, as well as with special silicone rubbers. Fluoro rubbers for improved heat and solvent resistance are coming into the picture. For the same purpose can be mentioned "ADDUCT" rubbers (diene rubber-alkyl mercaptan reaction products), polyacrylics, and nitrile silicone rubbers. A pourable rubber of value in the fabrication of a neutron shield and "ADDUCT" rubber coated cloth for a proposed nuclear powered airship have been announced.

International developments in synthetic rubber have been very impressive. SBR plants in Italy, Germany and England are now in full production, as well as a butyl rubber facility in France. Plants are being constructed in Japan and the Netherlands, with additional SBR facilities slated for France, Brazil, Australia, and possibly others such as Argentina and India. A neoprene plant is being constructed in Northern Ireland, and small specialty rubber plants have been completed in Germany, the Netherlands, and Japan. The synthetic rubber industry is also well advanced behind the Iron Curtain, and a recent study of the rubbers produced there indicated considerable similarity to those produced here.

Predictions are always difficult in an industry with a rapidly changing technology. It seems reasonable, however, to expect that synthetics will increase their already large share of the market since each new elastomer developed, with its special properties, will be capable of performance impossible by natural rubber. On the other hand, natural rubber interests are replanting and improving the efficiencies of their plantations, and will fight vigorously for an increasing share of the market for general purpose rubbers.

About the Author

Dr. James D. D'Ianni, assistant to the vice president, research and development, Goodyear Tire & Rubber Co., joined the company in 1938. He graduated from the University of Akron in 1934 and received his Ph.D. degree in organic chemistry from the University of Wisconsin in 1938. Since joining Goodyear, he has been a research chemist, supervisor of synthetic rubber organic research, section head of rubber chemical derivatives, section head in charge of vinyl polymers and synthetic rubber and section head in charge of diene and vinyl polymer research. Dr. D'Ianni assumed his present duties in 1952. He is active in a number of technical societies and institutes.



Acetaldehyde—MONTECATINI

Application: A process for manufacturing acetaldehyde by means of catalytic hydration of acetylene.

Charge: Acetylene, 98 percent pure.

Product: Acetaldehyde, having a purity of 99.5 percent.

Description: Acetaldehyde is obtained by direct hydration of actylene, according to the following equation:

$$CH \equiv CH + H_2O \rightarrow CH_3 \cdot CHO$$

This reaction, catalyzed by mercuric ion, takes place by injecting gaseous acetylene into a mercuric sulphate solution, acidified by H_2SO_4. The acetaldehyde produced tends to oxidize into acetic acid, thus reducing the mercuric ions to metallic mercury, according to the reaction:

$$CH_3 \cdot CHO + H_2O + Hg^{++} \rightarrow CH_3 \cdot COOH + Hg + 2H^+$$

As a result of this secondary reaction, the mercuric ion which is catalytically active, is transformed into metallic mercury, which does not have a catalytic action; thus, in order to prevent metallic mercury precipitation and to reoxidize it to mercuric ion, ferric sulphate is added to the catalyst solution. Mercury oxidation takes place by reducing ferric ion to ferrous ion, therefore a continuous partial extraction of the catalytic solution is needed for regeneration of ferric sulphate.

The catalyst solution is continuously withdrawn and sent to the regenerator, after removal of mercury-containing muds; said muds are periodically hot-treated in order to recover metallic Hg. Regeneration of catalyst solution comprises a hot-treatment with nitric acid in the presence of an air stream blown in the solution. Nitrogen oxide is produced; ferrous ion is oxidized to ferric ion.

The regenerated solution is recycled to the acetylene hydration reactor. The latter operates adiabatically and the residence time of acetaldehyde in the catalytic solution is calculated in such a way to minimize side-reactions.

Acetaldehyde vapors, mixed with steam and unreacted acetylene overflow from the top of the reactor. The effluent mixture is then cooled in three subsequent steps.

In a first cooler, temperature is lowered to about 60° C; the condensate consists almost entirely of water which is sent back to the reactor. The gaseous mixture is then admitted into a cooling tower where it is washed by an 8 percent acetaldehyde solution flowing from the following absorption tower. After leaving the cooling tower, the gaseous mixture is cooled again to about 30° C in a final surface cooler and is subsequently conveyed to the absorption tower for recovering acetaldehyde as an aqueous solution. Unreacted acetylene, together with inert gas contained in the starting gas feed flows from top of absorption tower and is sent back to reactor, while a small portion of it is continuously purged.

The purged gases, still containing acetylene, are sent to acetylene recovery which can be carried out by conventional means: in case the acetaldehyde unit is coupled to a methane cracking unit for the production of acetylene, the purged gases are sent to the main raw acetylene gasholder; thus they follow the concentration process of the acetylene production unit.

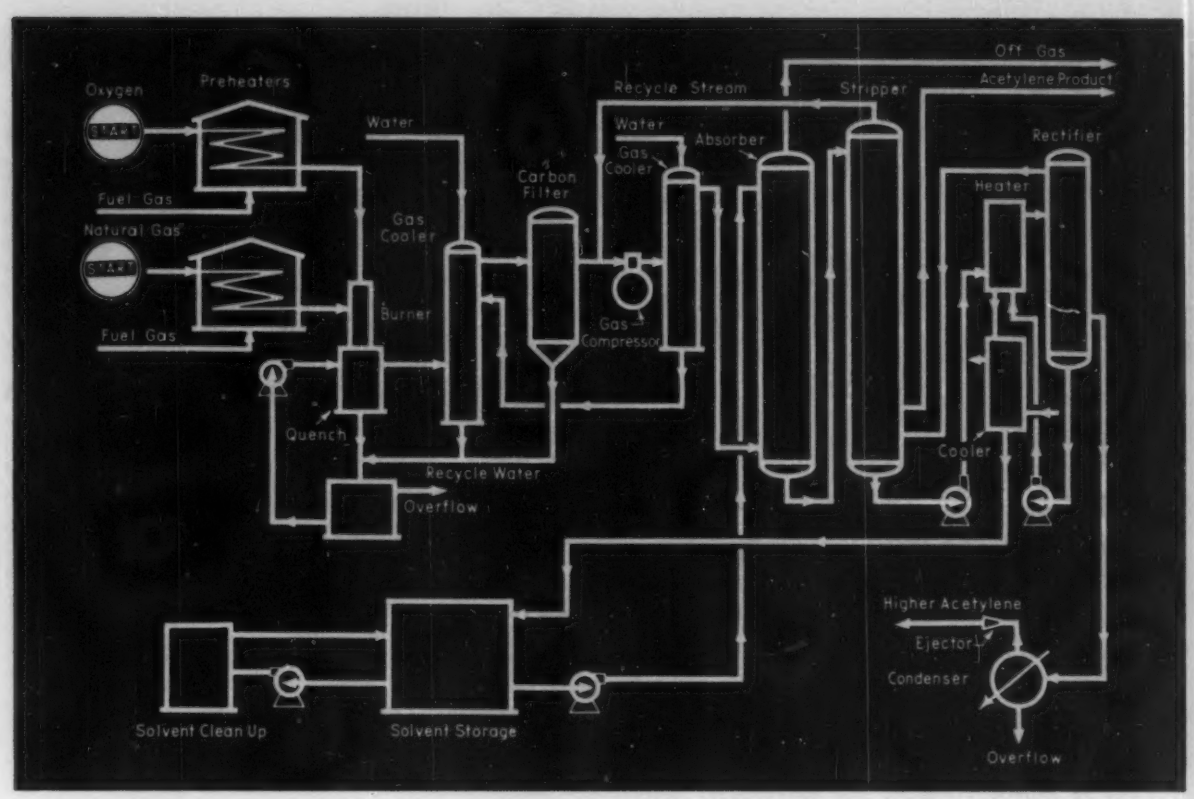
From the bottom of the absorption tower an acetaldehyde aqueous solution of 8 percent strength is obtained; this is sent first to the cooling tower and then to a collecting tank. The solution is pumped, through a pre-heater, to the distillation tower, from the top of which pure acetaldehyde, having a 99.5 percent content is obtained, by condensation, as the final product. The small acetylene amount evolved during acetaldehyde condensation is recycled back to the reactor.

From the bottom of the distillation tower a mixture of water and by-products is continuously drained off.

Operating Conditions: the reactor operates at a temperature of about 85° C and the plant is run substantially at atmospheric pressure.

Yields: Total yield of acetaldehyde is 95 percent based on acetylene consumption.

Commercial Installations: a large industrial plant is in operation at Montecatini Works of Novara, Italy.



Acetylene (BASF)—CHEMICAL CONSTRUCTION CORPORATION

Application: A process for making acetylene.

Charge: Natural gas and other hydrocarbons up to and including light naphtha; oxygen, 95-98 percent purity.

Product: Acetylene of 99+ percent purity.

Description: Oxygen and natural gas are preheated separately in direct-fired heaters to about 1,200° F. The charge gases are mixed in a molar ratio of 0.60:1.00 oxygen:methane upon being fed to the converter. The converter is a vertical cylindrical unit comprising three sections: mixing chamber, flame room, and quench chamber. The mixing chamber is specially designed to provide rapid yet thorough mixing of oxygen and methane.

The mixed gases are fed to the flame room through a plurality of ports in a burner block designed to prevent backtravel or blowoff. In the flame, methane is cracked according to the endothermic reaction:

$$2CH_4 \rightarrow C_2H_2 + 3H_2$$

The combustion of methane supplies sensible and cracking heats. About one-third of the entering methane is cracked; most of the remainder is burned. Over-all conversion of methane is 90-95 percent; conversion of oxygen is complete. The flame reaches an average temperature of 2,700° F. Operating pressure is slightly above atmospheric. Residence time is 0.001-0.01 seconds.

The acetylene is cooled rapidly by a series of sprays located in the lower part of the converter. The cooled gases pass directly to a spray chamber where most of the water is condensed. The gases leave the chamber at 100° F and have the following typical composition (dry basis):

Acetylene	8.5 percent
Hydrogen	57.0 percent
Carbon monoxide	25.3 percent
Carbon dioxide	3.7 percent
Methane	4.0 percent
Higher Acetylenes	0.5 percent
Inerts	1.0 percent
Total	100.0 percent

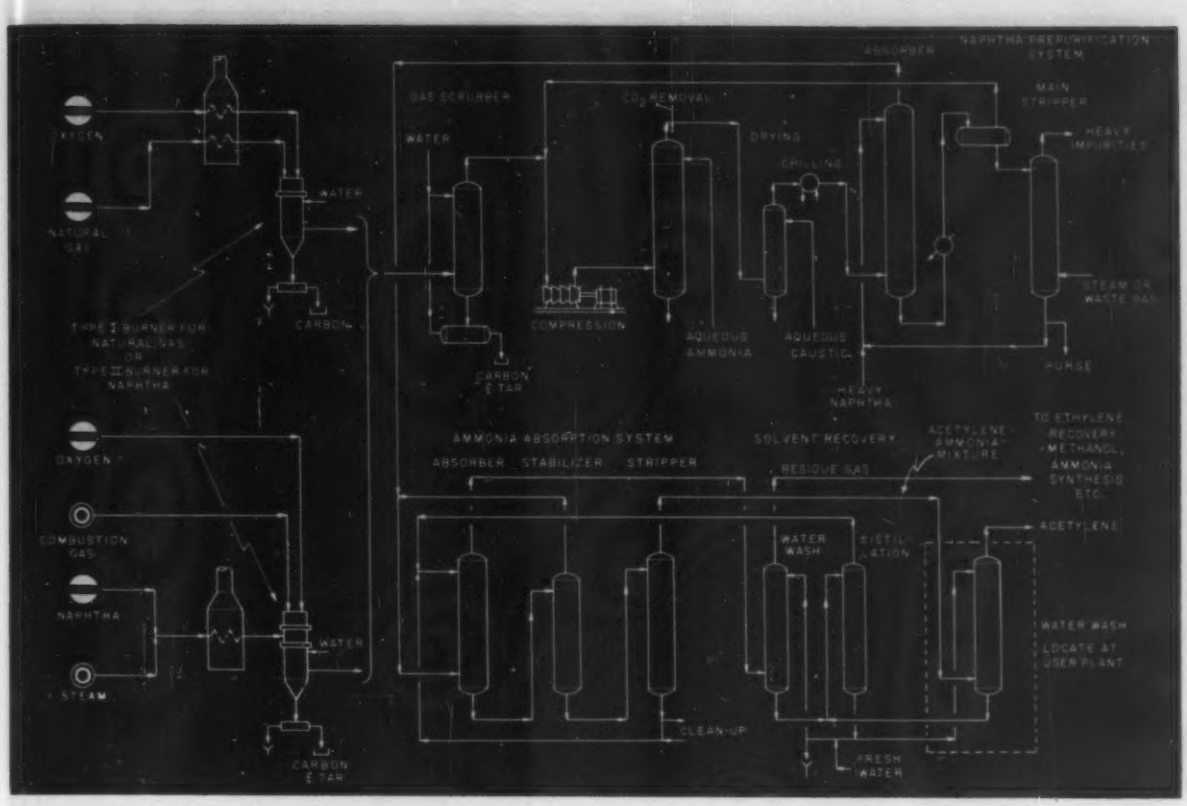
Before the cracked gas can be compressed and separated, residual soot must be removed. The clean cracked gas is then compressed to the head pressure (165 psig) of the concentration system.

The cracked gas passes from the compressor to the main absorber, where acetylene is removed by a selective solvent which shows a high acetylene: carbon dioxide selectivity. Carbon dioxide is removed from the rich solvent by a flashing and stripping operation. Acetylene is stripped from the solvent by conventional flashing and fractionation. Higher acetylenes and water are removed by stripping under reduced pressure. The product acetylene has a purity of 99+ percent with major impurities being methylacetylene, propadiene and carbon dioxide.

Yields: The over-all process yield of acetylene, based on carbon in the natural gas, is 30 percent.

Commercial Installations: This process or a variation is used by Carbide and Carbon Chemicals Company, Texas City, Texas; Monsanto Chemical Company, Texas City, Texas; American Cyanamid Company, Fortier, La.; Rohm and Haas Company, Deer Park, Texas.

Reference: PETROLEUM REFINER, Dec.'54,p160.



Acetylene (SBA-Kellogg)—THE M. W. KELLOGG COMPANY

Application: A process for the manufacture of acetylene and ethylene.

Charge: Natural gas, propane, butane, naphtha, refinery gas, or other liquid feedstocks.

Product: High purity acetylene, ethylene.

Description: The Type I Burner is designed for generation of acetylene from natural gas. This is a partial combustion reaction in which oxygen and the feed gas are preheated separately and then mixed and burned. The oxygen burns part of the feedstock, providing the heat necessary to crack the rest of the feed to acetylene and hydrogen. Small quantities of the higher acetylenes are also formed, and a part of the feed is completely cracked to carbon.

The mixture of pyrolysis and combustion products is then immediately quenched to prevent overcracking and other undesirable side reactions. This quench is an integral part of the burner and also serves to flush out the carbon and tar. The "straight-through" burner design eliminates dead spots where carbon deposits might form. The reaction chamber is water cooled, and the burner design permits easy installation of alternate reaction chambers of varying lengths as might be required by changes in operating conditions.

Maximum acetylene yields are achieved by using the highest possible preheat temperature, minimizing the amount of combustion required, and increasing the acetylene concentration to the recovery unit by reducing the dilution from combustion products. The burner itself is completely metallic, using no refractories, and requires little maintenance. Burners of 15 metric tons per day acetylene capacity are available.

The Type II Burner is used with liquid feedstocks. This design provides for injection of vaporized feed into an independently formed gas-oxygen flame. Oxygen and fuel gas, mixed with a pre-selected amount of superheated steam, are injected through the head of the combustion chamber. The combustion chamber is formed from a simple, water-cooled refractory ring, the only non-metallic element in the burner. The combustion chamber is also protected by a curtain of steam injected parallel to the walls along the perimeter.

Naphtha, or other liquid feedstock, is mixed with a small quantity of steam, preheated, and injected at high velocity into the burner just below the flame combustion zone. The feedstock cracks primarily to ethylene and acetylene, the ratio of the two being controlled by adjusting the ratio of feed to oxygen and fuel gas. Higher boiling acetylenes and olefins are also formed, and a small amount of feedstock is completely cracked to carbon and tar. As in the case of the Type I Burner, the pyrolysis products are then water quenched after a controlled reaction time.

The burner effluent gas passes through a scrubbing system to remove the carbon and tar which has not been removed by the quench water in the burner. Depending on the feed gas and desired acetylene purity, discharge pressure may range from 25 to 100 psig.

Following compression, the CO_2 is removed from the gas by scrubbing with an aqueous ammonia-ammonium carbonate solution, followed by a caustic wash. The gas is then dried and cooled.

Precise control of product purity is obtained in the two-solvent recovery system by using heavy naphtha and ammonia for solvents. Purities as high as 99.8 percent can be readily achieved, and in general any designated impurity can be reduced below the value established by the requirements of the user plant.

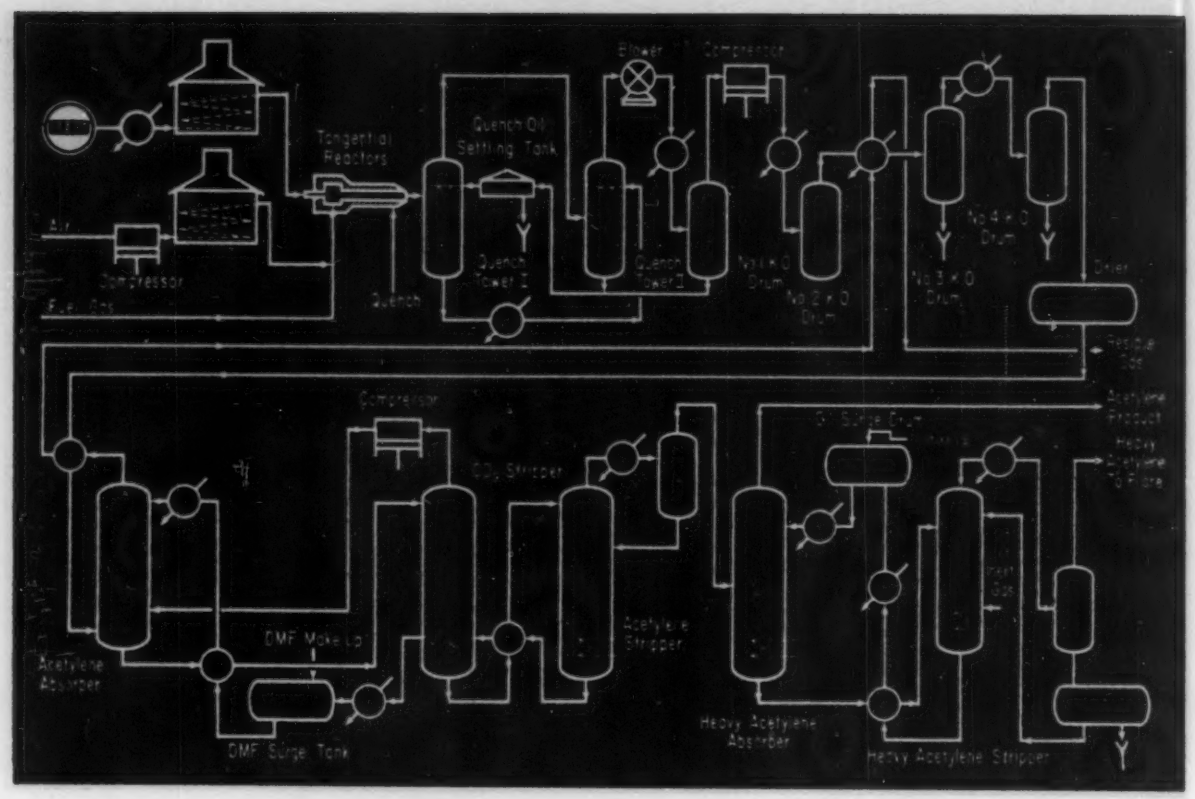
The acetylene-ammonia mixture from the final product stripper is available, under pressure, for safe transport to the acetylene user plant. Final purification to remove the ammonia can be carried out by water wash at the user plant after its pressure is reduced to levels safe for handling concentrated acetylene.

When processing liquid feedstocks, ethylene is a major coproduct recoverable from the residue gas produced in this unit. The ratio of ethylene to acetylene can be controlled over a wide range, varying from less than 0.10 to over 3.0 by weight.

Yields: Acetylene weight percent yield on naphtha varies from 36 to 16 percent over the E/A (wt.) range of 0.1 to 2.0. Acetylene plus Ethylene weight percent yields on naphtha vary from 40 to 50 percent over the same E/A range. Acetylene yield from 95 percent methane feed varies between 24.4 and 25.2 weight percent on feed.

Commercial Installations: A Type I Burner plant is under construction. Several Type II Burner plants are in the engineering stage. A Type I Burner plant is now in operation in France.

References: PETROLEUM REFINER, Nov.'58,p.180.



Acetylene— PHILLIPS PETROLEUM COMPANY

Application: A process for manufacturing acetylene and/or ethylene.

Charge: A wide range of feedstocks from methane through naphtha can be utilized.

Product: The primary product is high purity acetylene; however, the process is flexible enough to permit production of both acetylene and ethylene.

Description: Preheated air or oxygen and fuel (gas or oil) are introduced tangentially into the expanded precombustion section of the cylindrical refractory lined reactors. Preheated feedstock is introduced axially and is mixed intimately with the hot combustion products from the tangential feed. Acetylene is produced under the favorable conditions of high temperature, low pressure (essentially atmospheric) and very short contact time, in the smaller diameter portion of the reactor. Reaction is stopped by a primary water quench near the outlet end of the reactor.

Following the primary quench, the gases are further cooled in a two-tower, recirculating oil quench system. Use of oil, rather than water, for this secondary quench removes heat from the gases at a high-temperature level which permits the dissipation of heat through fin coolers or heat recovery by exchange. In addition, any small amounts of tar or heavy olefinic hydrocarbons formed in the reactor are absorbed in the quench oil system. Removal of these components permits drying and acetylene absorption to be carried out without a prior deoiling step.

Compression of the gases from the secondary quench tower requires only moderate power since a low pressure recovery system is used. The compressed gases then pass through a series of heat exchangers, knockout drums and bauxite drier to remove moisture prior to absorption in the dimethylformamide (DMF) recovery section. After drying, the gases are processed in the DMF acetylene absorber which selectively absorbs all the acetylenic compounds of the gas stream at low pressure and temperature. Use of a dry feed not only eliminates any problem of DMF hydrolysis, but also permits low temperature operation, greatly reducing the DMF circulation requirements.

Residue gas passes overhead from the DMF absorber and the acetylene rich solution from the bottom of the column passes next to a CO_2 stripper. Overhead from the CO_2 stripper is recycled to the DMF absorber to recover the small quantity of acetylene contained in this stream. From the CO_2 stripper the rich DMF stream enters the acetylene stripper where acetylene is removed from the rich DMF solution and passes in gaseous form out the column overhead. The lean DMF stream is then recirculated to the DMF absorber. The gas stream leaving the top of the acetylene stripper is rich in acetylenes but contains substituted acetylenes which are then removed in order to further purify the product.

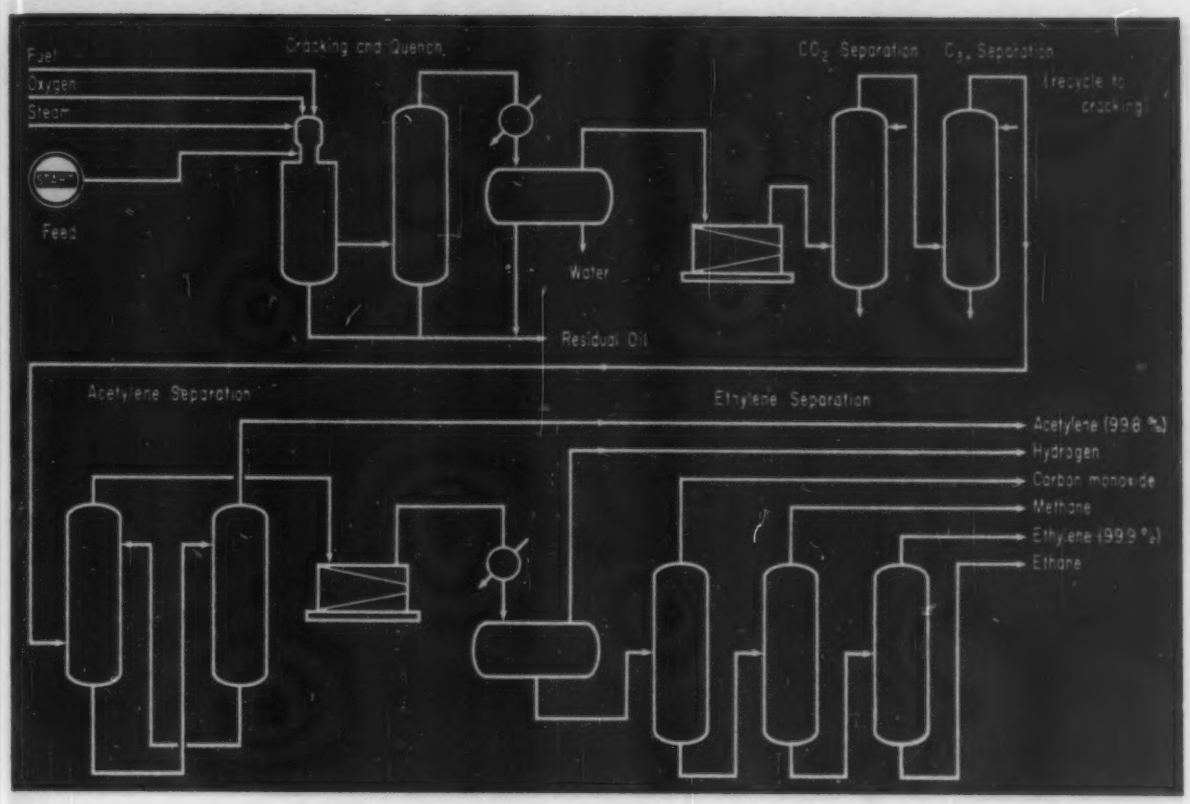
The last step in the purification is accomplished in the heavy acetylene absorber which uses heptane as the absorber oil. Having dry feed for the heavy acetylene absorber again permits a low-temperature operation which in turn decreases heptane absorbent circulation and also minimizes loss of heptane in the overhead acetylene product. The heavy acetylenes contained in the rich heptane from the bottom of heavy acetylene absorber are removed as an overhead product in a stripper. Lean oil from the bottom of the stripper is recirculated to the heavy acetylene absorber column.

Yields: Typical yields for various feedstocks and oxidants are:

Hydrocarbon Feed	95 Percent Ethane	97 Percent Propane	99 Percent Butane	Debutanised Natural Gasoline		
				ASTM Dist, °F.		
				IBP		91
				95%		238
				Dry Point		262
				Residue, Percent		1.4
				RVP, psi. @ 60F		13.45
Oxidising Agent	O_2	Air	Air	Air	Air	Air
Effluent Analysis, Mol Percent (Air and Oxygen as Oxidants)						
Acetylene Yield[1]	47.2	40.1	45.7	43.9	26.5	18.1
Ethylene Yield[1]	7.3	8.3	13.1	10.1	28.5	36.9
Acetylene/Ethylene ratio	6.5:1	5:1	3.5:1	4:1	1:1	0.5:1

[1] Weight percent of Axial Hydrocarbon Feed.

Licensing: The process is offered for license through the Perco Division of Phillips Petroleum Company.



Acetylene and Ethylene—HOECHST-UHDE CORPORATION

Application: The Hoechst high temperature pyrolysis process for manufacturing acetylene and ethylene from hydrocarbons.

Charge: Feed stocks ranging from methane through middle distillates.

Products: Acetylene of 99.8 percent purity and ethylene of 99.9 percent purity.

Description: Farbwerke Hoechst AG, Frankfurt/Main-Hoechst, Germany, has developed a process which produces a high yield of acetylene and ethylene from hydrocarbon feed stocks. The large amount of high-temperature heat required for the cracking of hydrocarbons into acetylene and ethylene is obtained by combustion of gaseous or liquid fuels with oxygen in a newly developed burner. Combustion with oxygen minimizes the gas volume and permits the use of tail gas as burner fuel. The burner heat release exceeds 10^8 Btu/ft^{3}hr. Its high capacity and all-metal construction minimizes size and weight of the burner. The absence of ceramic parts permits rapid start-up and shut-down. The burner is water cooled and has a very low heat loss.

The feed stock is injected into the hot combustion gas. The mixture enters a reaction zone where the heat necessary to form acetylene and ethylene is transferred by direct contact, with a reaction time of about 0.001 second. An economical and reliable quench method prevents coke formation. The reactor-effluent gas is cooled in steam-generating equipment.

Condensed hydrocarbons are separated and the raw gas is compressed to moderate pressure. Its carbon dioxide and hydrogen sulfide contents are removed by contact with a newly developed absorption agent which is chemically stable, easily regenerated with low-temperature heat, and is non-corrosive. The gas is then cooled and dried, and the C_3 and heavier hydrocarbons are separated. Higher acetylenes, which tend to polymerize, are removed completely and recycled to the reactor.

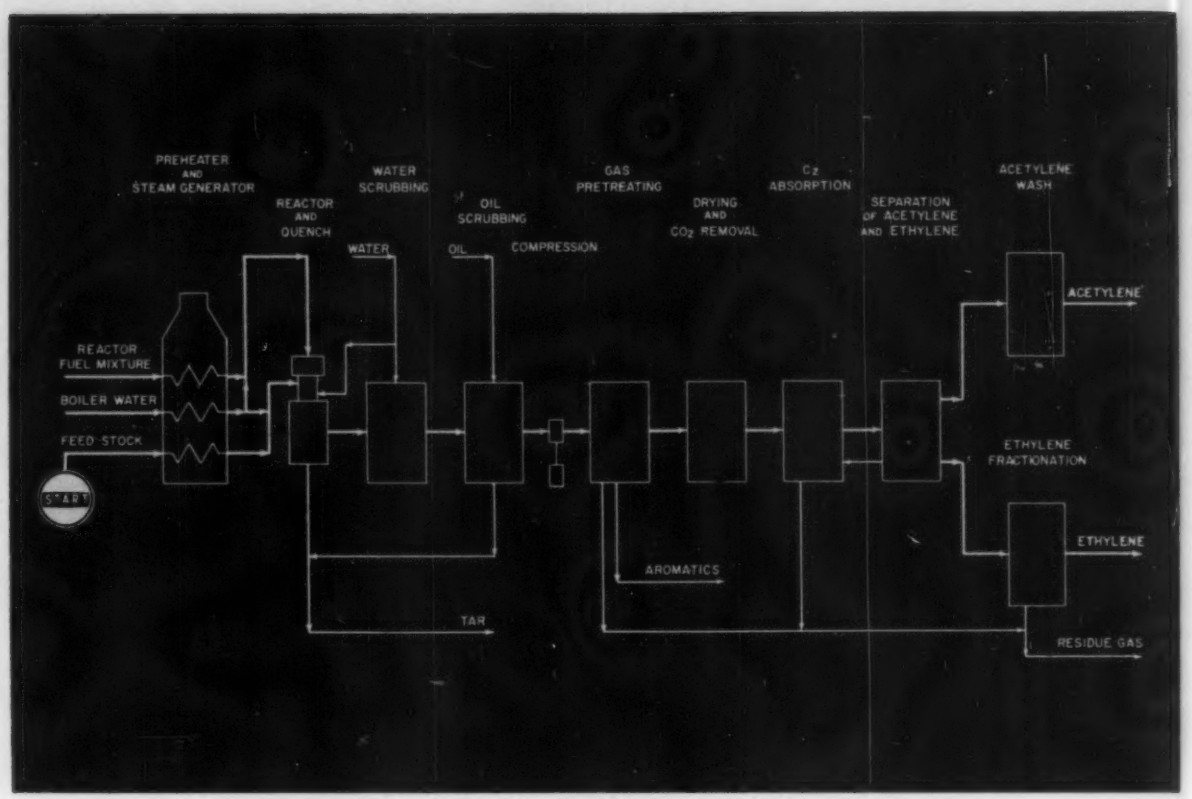
In the next step, a solvent is used to absorb the acetylene, which is recovered as a product of 99.8 percent purity, and higher. A solvent of high selectivity and absorptive power is utilized. This solvent is inexpensive, readily available, and non-corrosive. Regeneration is simple and economical, and solvent losses are low.

High-purity ethylene is separated from the remaining gas by a low-temperature process. The residual gas is rich in hydrogen and may be used as burner fuel. However, if burner fuel is available from other sources, the tail gas may be used for ammonia or methanol synthesis.

Yields: Yields of 50 to 54 wt. percent of acetylene plus ethylene are obtained from light virgin naphtha. A 40 wt. percent yield of acetylene is obtained from methane. These yields are net and after process losses. The ratio of acetylene to ethylene obtained from the burner may be varied from 80:20 to lower than 30:70 by changing operating conditions.

Commercial Installation: The construction of a plant designed to produce 100,000,000 lb/yr of acetylene plus ethylene is being completed at the Hoechst plant of Farbwerke Hoechst AG in Germany, and will be placed in operation in early 1960.

References: Further information is available from Hoechst-Uhde Corporation, Empire State Building, Suite 8204, New York 1, N.Y.



Acetylene and Ethylene (EASTMAN PROCESS)—STONE & WEBSTER ENGINEERING CORP.

Application: A process for the simultaneous production of acetylene and ethylene.

Charge: Ethane, propane, butane, light naphtha.

Products: Acetylene, ethylene, synthesis gas.

Description: The hydrocarbon feed is converted into acetylene, ethylene and byproduct gas by short time pyrolysis in a stream of hot combustion products in a reactor of special design. The reactor consists of five elements in series: a fuel burner, a combustion chamber, a feed injection zone, a reaction zone and a quenching section.

Fuel gas and air, or oxygen, are burned in the combustion chamber, and the hot gases enter the mixing duct at high velocity. The hydrocarbon to be pyrolyzed is injected into the turbulent combustion gas stream where rapid and uniform mixing is attained. The reaction section provides the additional small residence time required for completing the pyrolysis to maximum yields of acetylene and ethylene, after which the gas mixture is rapidly quenched by water sprays to relatively low temperatures.

Steam is introduced with the fuel and oxygen, to temper the combustion temperature and to serve as a heat carrier. Steam is also admitted with the feed stock as a diluent, producing a partial pressure favorable to the desired pyrolysis reaction. The proportion of acetylene to ethylene is governed principally by the reaction temperature level, which may be varied easily by changing the quantity of combustion gas used, or the quantity of feed injected. Acetylene to ethylene ratios of 0.3/1 up to 4/1 have been demonstrated.

A water quench spray is located at the outlet of the reaction zone, and the effluent passes into a tar knockout drum where most of the small amount of tar made settles out and is drawn off. The gases then pass into a water scrubbing tower where they are cooled to about 100° F, and the steam in the gases is condensed. In the oil scrubber which follows, a circulated stream of oil removes fine particles of tar and heavy oils from the gas. Cleanup of the circulating oil is effected by steam in a stripping column. The residue tarry oil from this stripper is mixed with the tar from the quench drum, so that a freely flowing material results.

The scrubbed gas is compressed and sent to a pretreating section, where oil absorption removes material heavier than acetylene and ethylene.

Conventional carbon dioxide removal and dehydration treatment are the final steps in preparing the gas for entry into the recovery system.

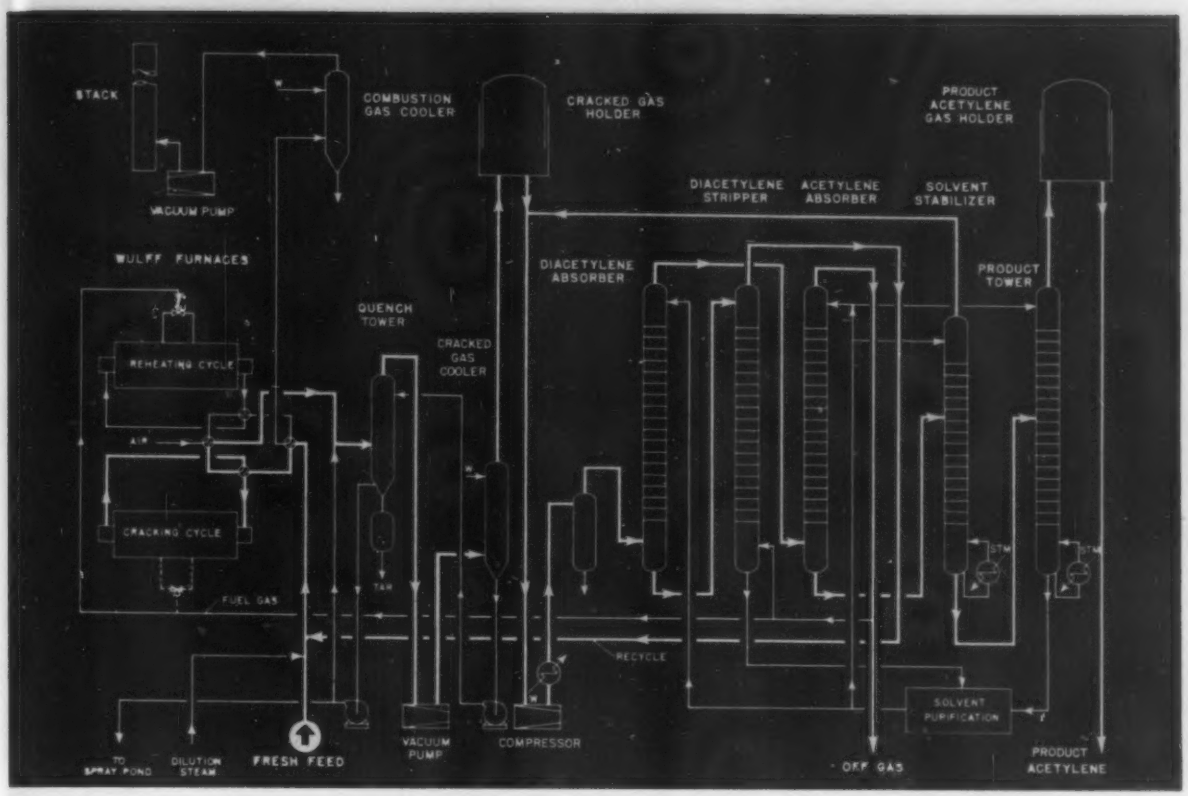
The recovery system employs a combination of absorption and extraction steps with hydrocarbon and organic solvents to recover acetylene and ethylene from the gas. Suitable purification steps are included to produce acetylene and ethylene at high purities.

Operating Conditions: The reactor operates substantially at atmospheric pressure and at a flame temperature of about 2,000° C.

Yields: A combined yield of acetylene and ethylene of over 50 weight percent on the charge is obtained.

Commercial Installations: Reactor in commercial operation at Chemische Werke Hüls, Germany.

Reference: *Chem. Engr. Progress*, Vol.54, No.1, '58, p41-48.



Acetylene— WULFF PROCESS COMPANY

Application: A process of manufacturing acetylene.

Charge: Hydrocarbons ranging from methane through gas oil.

Product: Acetylene of high purity.

Description: The Wulff process employs a regenerative furnace to attain the high temperatures required to crack hydrocarbons to produce acetylene and ethylene. The furnace consists of three regenerative masses of ceramic checkers of special shape and material which, when assembled, form a large number of small longitudinal circular passages.

The furnace operates on a four phase cycle. First air is drawn into the furnace at one end, where it is preheated by contact with the hot checkers. Fuel is introduced into a first combustion chamber between the first and second ceramic masses and heats the second and third ceramic masses. The products of combustion leave the third mass at a low temperature. The charge stock, diluted with steam, is introduced at the opposite end of the furnace, preheated, cracked and quenched by passage through the three masses in series. The third step introduces in the same direction as the previous cracking phase with fuel now added in a second combustion chamber between the second and third masses. The fourth phase is to introduce feed stock and steam in the opposite direction to the second heating phase. Cracking temperatures for any feed are obtained with air-fuel combustion using less than one-half of the by-product off gases for fuel.

Operation of the furnace on a four phase cycle is controlled with a cycle timer operating interlocked four-way plug-type switch valves. Continuous flow of cracked gas is achieved by installing the furnaces in pairs. Four switch valves serve the pair of furnaces.

For maximum acetylene production the furnaces are operated at reduced pressure. During the heating period the products of combustion leaving the furnace are cooled, sent to the combustion gas vacuum pump and discharged into a stack. The cracked gas from the furnace passes to a quench system for condensation of most of the dilution steam and the small amount of liquid products and tars formed in the cracking operation. The remaining gas is compressed to atmospheric pressure by the cracked gas vacuum pump, is cooled and flows to the cracked gas holder.

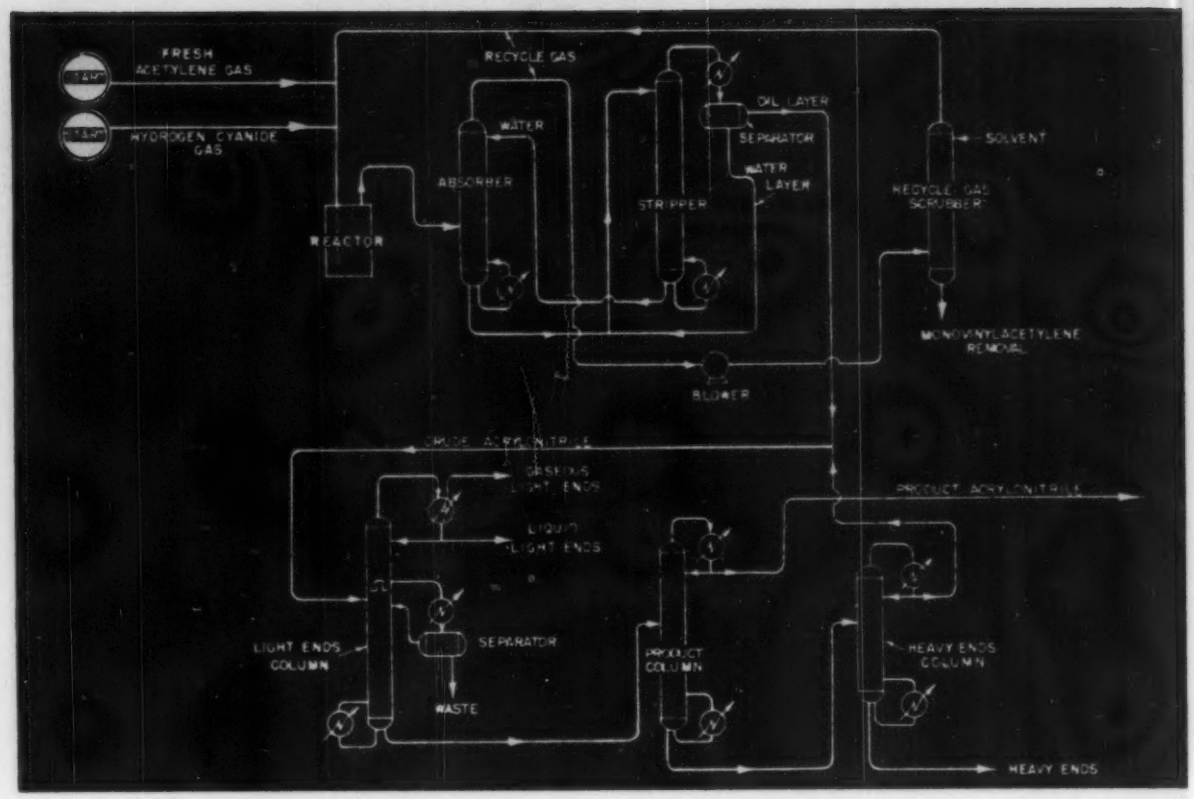
Recovery and purification of the acetylene in the cracked gas is accomplished with a selective solvent system using dimethylformamide. The cracked gas from the gas holder compressed to ten atmospheres goes to the first absorption column, where diacetylene, water and C_4 and heavier components are removed. Acetylene and part of the other gases are then absorbed in the main absorber, the overhead being off gas. Liquid from the main absorber then goes to two columns in series for purification of the acetylene. The solvent from the diacetylene column is stripped and redistilled. Solvent from the main absorber, after removing the acetylene, is stripped, cooled and returned to storage. The gas from both stripping operations is recycled to the furnace.

Where ethylene is also recovered, the off gas from the acetylene absorber is further compressed and fed to a conventional ethylene purification system. When the feed is ethane or heavier, acetylene and ethylene may be produced in any desired ratio by a simple adjustment of the cracking conditions.

Yields: The yield to acetylene plus ethylene with C_2 and heavier feeds will exceed 50 percent. The process is not sensitive to feed composition and broad cuts may be used with good yields.

Commercial Installations: A demonstration plant has been operated since 1952 by Wulff Process Company in Los Angeles producing acetylene in cylinders for welding purposes. The process is available from The Lummus Co., The Fluor Corp., and Koppers Co.

References: Petroleum Refiner, Sept.'53,p162. *Industrial and Engineering Chemistry,* Vol.45,Dec.'53,p2596. *Chemical Engineering Progress,* July'54,p372.



Acrylonitrile—AMERICAN CYANAMID COMPANY

Application: A process for manufacturing acrylonitrile from acetylene and hydrogen cyanide.

Charge: Acetylene gas (99 percent purity); hydrogen cyanide gas (99+ percent purity).

Product: Acrylonitrile liquid of 99.5 percent purity.

Description: Acrylonitrile may be produced either by the dehydration of ethylene cyanohydrin or by the direct combination of acetylene and hydrogen cyanide. The latter method is known as the "natural gas process." It is the more important method today, commercially, and accordingly will be described here.

Acetylene and hydrogen cyanide in a ratio of 6:1 form the reactor charge. The reactor is a rubber-lined cylindrical vessel containing liquid catalyst to a depth of several feet. The reactants are injected separately under the liquid surface. About 15 percent of the acetylene is converted, and this consumes practically all of the hydrogen cyanide.

The aqueous catalyst consists of cuprous chloride, hydrogen chloride, and alkali chlorides in 36 weight percent water. All salts are in solution at 175° F which is also the reaction temperature. Yields of 1.5 pounds of acrylonitrile per hour-foot^3 of solution are obtained. The catalyst must be regenerated to prevent deactivation.

The reaction pressure is 2-5 pounds above atmospheric.

The reaction products pass to an absorber, the lean gas from which contains acetylene and divinylacetylene. The latter constituent is removed in a separate scrubbing operation. The residual acetylene is recycled through a blower to the reactor charge.

The absorber is operated at a water rate such that a three percent acrylonitrile solution is withdrawn as bottoms. This stream is sent to the stripper, from which a crude acrylonitrile-water azeotrope is recycled to the stripper feed. The oil layer, or "crude acrylonitrile," is sent to a distillation train for separation and purification.

The concentration of acrylonitrile in the crude solution is about 75 weight percent; that of the materials other than water is about 15 weight percent.

The first tower in the distillation train (light ends column) enables the overhead removal of materials boiling below acrylonitrile. Acetylene and monovinylacetylene pass off as gases.

Product acrylonitrile, having a purity of about 99.5 percent on a dry basis, is removed as overhead from the second column. The operating head pressure is about 140 mm Hg abs. The bottoms stream contains heavy ends plus a significant amount of acrylonitrile.

The third tower in the train, the heavy ends column, serves to recover acrylonitrile from the product column bottoms. The heavy ends column operates at a head pressure of 120-150 mm Hg abs. The recovered acrylonitrile is not specification-grade and must be recycled to the light ends column.

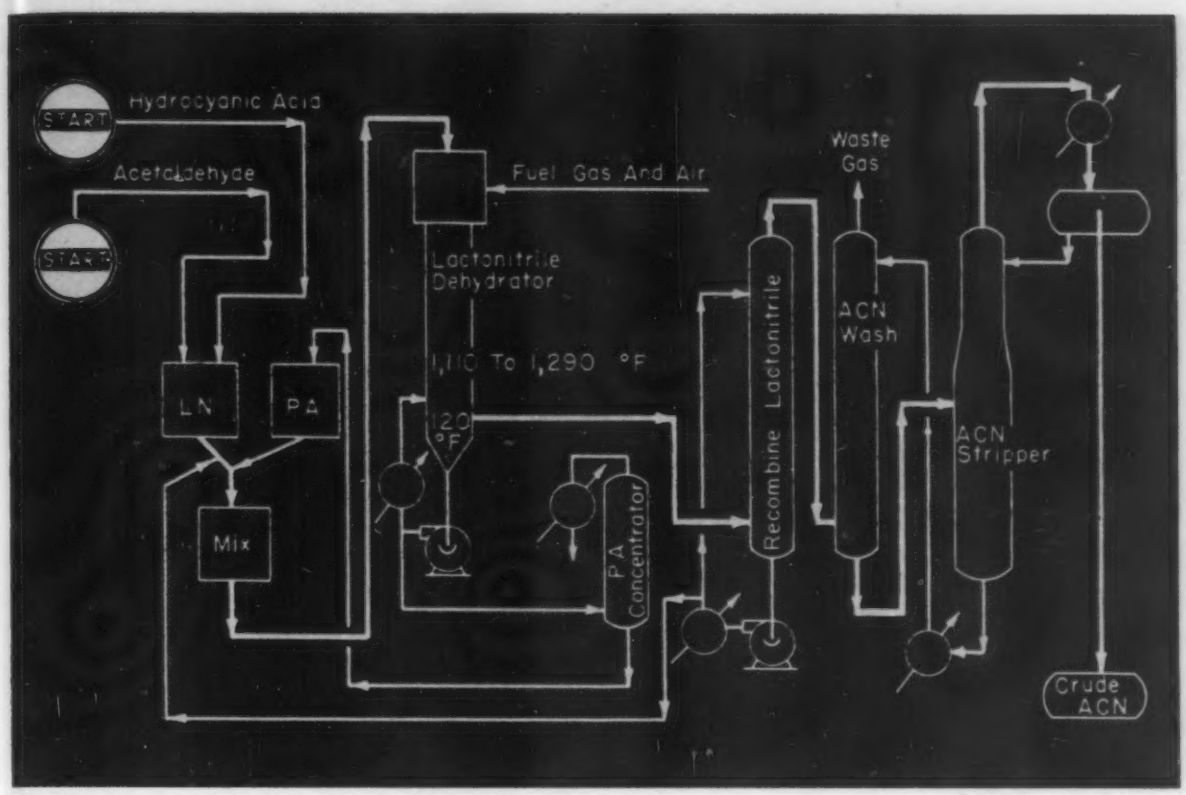
The product acrylonitrile has a boiling range of 169°-173° F.

Operating Conditions: The important operating conditions are those in the reactor. They are defined in the above text.

Yields: Typical over-all process yields are:
Acrylonitrile from HCN, 85 percent.
Acrylonitrile from C_2H_2, 75 percent.

Commercial Installations: Plants utilizing the methane process are: Monsanto Chemical Company, Texas City, Texas; American Cyanamid Company, Fortier, La.: The B. F. Goodrich Company, Calvert City, Ky.

References: "The Manufacture of Acrylonitrile From Natural Gas," J. T. Thurston, E. L. Carpenter, and F. Derbenwick of American Cyanamid Co., Fourth World Petroleum Congress, Rome, Italy.



Acrylonitrile (Knapsack)—HOECHST-UHDE CORPORATION

Application: A process for the manufacture of acrylonitrile from acetaldehyde and hydrocyanic acid.

Description: Lactonitrile of 97-98 percent purity is produced from acetaldehyde and hydrocyanic acid at a pH of 7.0-7.5 and a temperature of 50°-65° F, according to the following reaction:

$$CH_3CHO + HCN \rightarrow CH_3CH(OH)CN + 30.4\ BTU$$

Lactonitrile is mixed with 80-85 percent aqueous phosphoric acid in a molecular ratio of 3:1 and is sprayed into a reaction furnace where the mixture is heated within a fraction of a second to 1110°-1290° F by contact with high-temperature combustion gas. The hot gas, at 1800°-2700° F, is obtained by combustion of fuel gas with 90 percent of the theoretical air requirement. The reaction gases are quenched at the furnace outlet by a recirculating stream of 30 percent aqueous phosphoric acid. Approximately 75 percent of the lactonitrile is thus converted to acrylonitrile and water. Most of the remainder splits to form acetaldehyde and hydrocyanic acid, and about 2-3 per cent saponifies to ammonium phosphate and lactic acid.

The 30 percent aqueous phosphoric acid from the quenching operation is reconcentrated to 80-85 percent and is recycled to the reaction furnace. The reaction gases are directed to a venturi scrubber where the remaining phosphoric acid mist is removed.

The hydrocyanic acid and acetaldehyde contained in the reaction gases are converted to lactonitrile in a recombining tower and the lactonitrile is pumped to the reaction furnace. The acrylonitrile content of the reaction gases is removed by absorption in water at 68° F. Recovery of crude acrylonitrile from the 2-3 percent aqueous solution is accomplished in a stripper by direct heating with steam.

The crude acrylonitrile is finally directed to a distillation section comprising two columns in a series. The water content is removed in the first column, as well as small quantities of lactonitrile, acetaldehyde, and hydrocyanic acid. Pure acrylonitrile is the overhead product from the second column. A residue of high-boiling nitriles, equivalent to 2.5-3 percent of the acrylonitrile production, is obtained from the bottom of the second column.

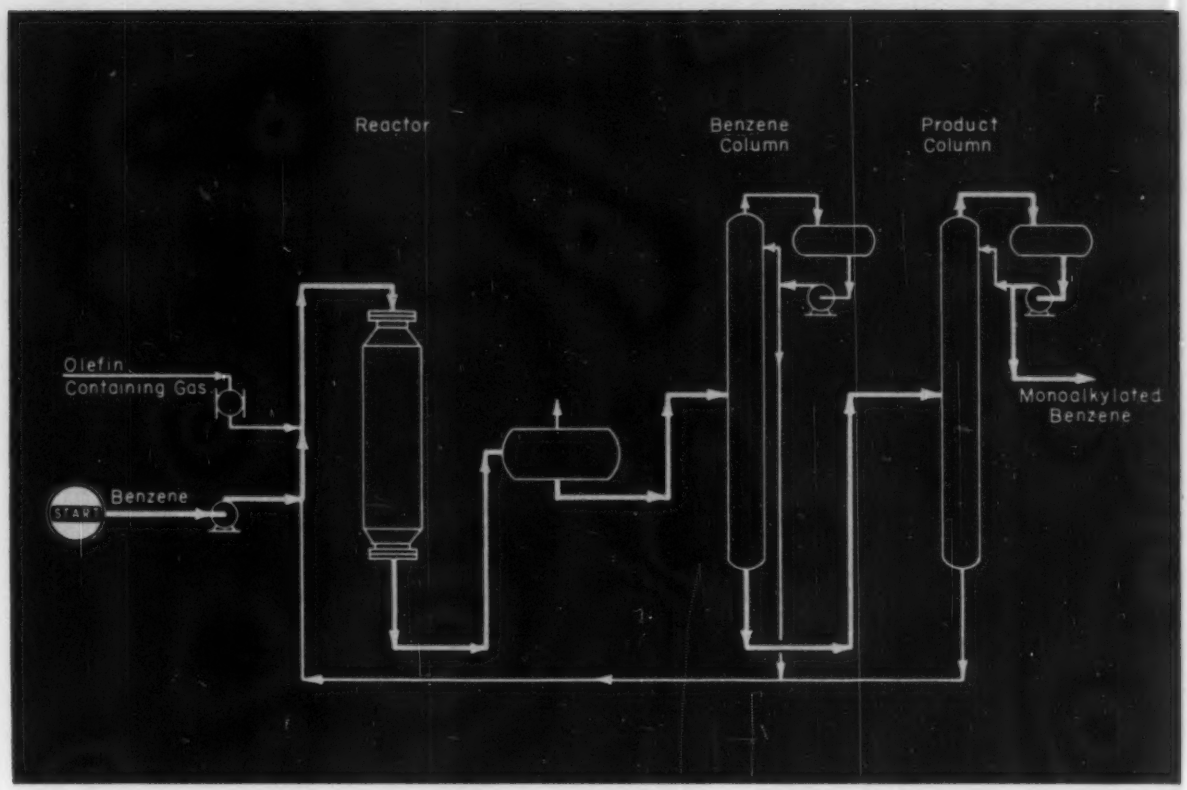
The problem of phosphoric acid corrosion at the high temperatures involved has been met through use of suitable materials. The ammonium phosphate produced by the 2-3 percent saponification of lactonitrile is concentrated in the recycle acid and crystallizes at a concentration of 15-20 percent in the lactonitrile mixture. It is removed by filtration. The ammonium phosphate production is approximately 7-8 pounds per 100 pounds of acrylonitrile produced. This material is at least as valuable as the equivalent phosphoric acid.

The acrylonitrile produced by the Knapsack Process does not contain any contaminants of an unsaturated nature which tend to polymerize, to promote the polymerization of the acrylonitrile, or to affect the quality of the polyacrylonitrile product. Therefore it is particularly suitable for the manufacture of high-quality polymers.

A pilot plant of 30 tons/month acrylonitrile capacity has been operated in the plant of Knapsack-Griesheim AG, near Cologne, Germany.

Yields: The yields of acrylonitrile based on the quantities of acetaldehyde and hydrocyanic acid reacted are 90 and 92 percent respectively, and may be improved as the development of the process is advanced.

References: Sennewald, K., Steil, K. H., *Chemie-Ingenieur Technik* No. 7, 440-446 (1958); Sennewald, K., "Acetaldehyde as Raw Material for Acrylonitrile", Paper presented at Fifth World Petroleum Congress, New York, 1959.



Alkar— UNIVERSAL OIL PRODUCTS COMPANY

Application: A process for alkylating aromatics with olefins to obtain a 100 percent yield of the monoalkylaromatics. The process may also be used to obtain substantially quantitative yields of dialykyl- and polyalkylaromatics.

The principal application of the process currently is in the manufacture of high-purity ethylbenzene for styrene production. It may also be used, however, to produce cumene, butylbenzene, diethylbenzene, diisopropylbenzene, or a combination of mono- or polyalkylbenzenes. Acetylene, if present in the feed gas, is selectively converted to 1,1-diphenylethane. Toluene, xylenes, and other aromatics also may be alkylated. It is possible to alkylate aromatics in a mixture with paraffins and naphthenes.

Charge: Benzene, or other aromatics, and an olefin-containing gas. This gas may be off-gas from catalytic cracking operations, off-gas from a demethanizer in an ethylene purification unit, or gases from the pyrolysis of hydrocarbons.

Products: Alkylaromatics of high purity and exceptionally low olefin content. The low olefin content is achieved because the unique catalyst is selectively active for alkylation reactions, polymerization of the olefin being virtually absent.

Process Description: The purified olefin-containing gas and feed benzene are combined with recycle benzene and recycle polyalkylaromatics. The combined feed is raised to reaction temperature and enters the reactor. Olefins in the feed gas are completely converted to alkylbenzenes. Polyalkylbenzenes and benzene are transalkylated to yield monoalkylated products.

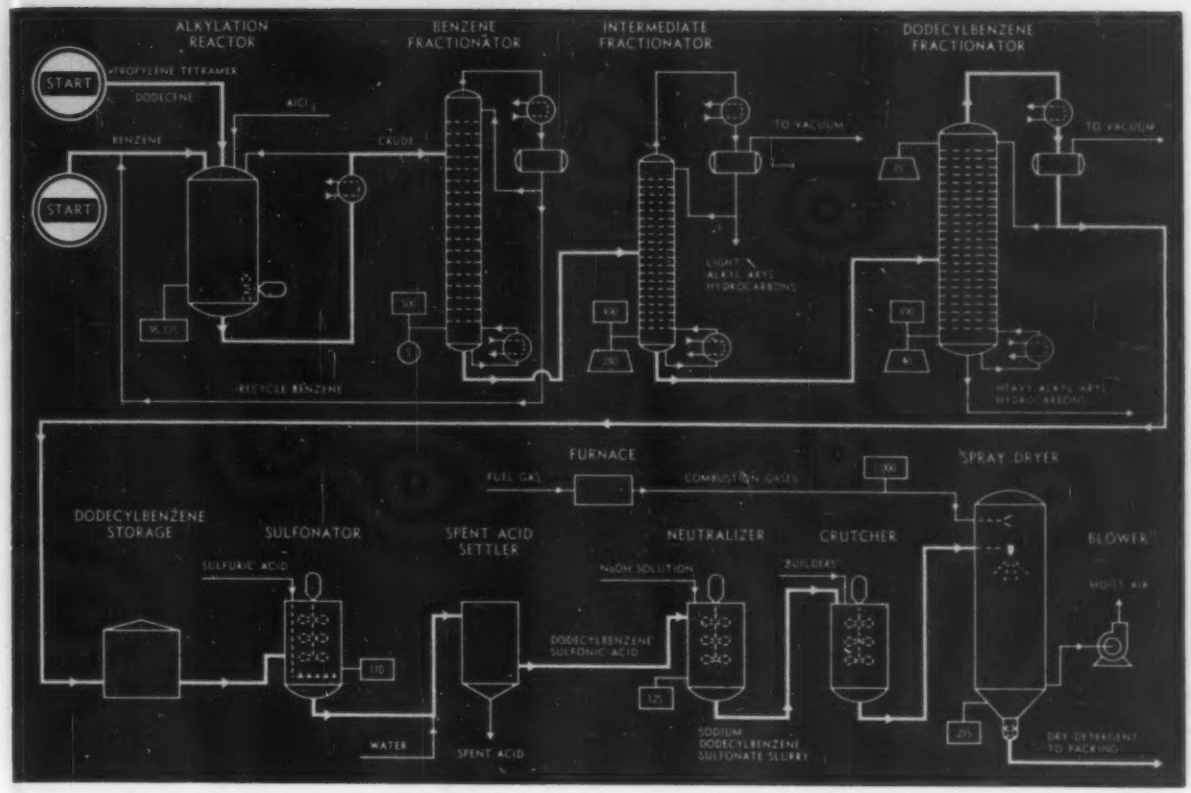
The reactor effluent is flashed to remove inert gases. The liquid from the flash drum is charged to the benzene column; recycle benzene is taken overhead and returned to the reactor. Alkylbenzenes are distilled to yield the monoalkylated product and the polyalkylbenzenes normally are recycled for transalkylation.

Operating Conditions: Operating conditions are moderate and no corrosion problems are encountered. Carbon steel may be used throughout the plant.

Yields: Olefins in the feed gas in concentrations as low as a few percent are converted completely on a one-pass basis. This is confirmed by the fact that no olefin is detectable in the spent gas by mass-spectrographic analysis. Any polyalkylaromatics produced may be quantitatively transalkylated to the monoalkylated product. Thus, a yield of virtually 100 percent of the desired product is obtained.

Commercial Operations: Several units have been licensed and are scheduled to be on stream in the near future.

References: *Oil & Gas J.*, Vol.56,No.13(Mar.31,'58); *Petroleum Week*, Mar.28,'58,p38.



Alkyl Aryl Sulfonates—CONTINENTAL OIL COMPANY

Application: A process for the manufacture of dodecylbenzene sulfonate synthetic detergents.

Charge: Benzene, dodecene (propylene tetramer), sulfuric acid, caustic soda, and "builders."

Product: Finished detergent containing 15 to 40 percent sodium dodecylbenzene sulfonate.

Description: This process involves reaction of dodecene with benzene in the presence of aluminum chloride catalyst; fractionation of the resulting crude mixture to recover the desired boiling range dodecylbenzene; sulfonation of the dodecylbenzene and subsequent neutralization of the sulfonic acid with caustic soda; blending the resulting slurry with chemical "builders"; and drying.

Dodecene (350°-420° F boiling range) is charged into a reaction vessel containing benzene and aluminum chloride. The reaction mixture is agitated and circulated through an external cooler to maintain the reaction temperature at about 115° F. maximum. An excess of benzene is used to suppress the formation of by-products. Aluminum chloride requirement is 5-10 weight percent of dodecene. The reaction may be carried out using hydrofluoric acid or sulfuric acid in place of aluminum chloride.

After removal of aluminum chloride sludge, the reaction mixture is fractionated to recover excess benzene which is recycled to the reaction, a light alkyl-aryl hydrocarbon, dodecylbenzene, and a heavy alkyl-aryl hydrocarbon. The dodecylbenzene is a water-white liquid having a boiling range of 530°-600° F.

Sulfonation of the dodecylbenzene may be carried out continuously or batch-wise under a variety of operating conditions using sulfuric acid (100 percent), oleum (usually 20 percent SO_3) or anhydrous sulfur trioxide. The optimum sulfonation temperature is usually in the range of 100°-400° F depending on the strength of acid employed, mechanical design of the equipment, etc. Removal of spent sulfuric acid from the sulfonic acid is facilitated by adding water to reduce the sulfuric acid strength to about 78 percent. When anhydrous sulfur trioxide is the sulfonating agent, there is no spent acid removal problem and the sulfonic acid is ready for further processing immediately after sulfonation.

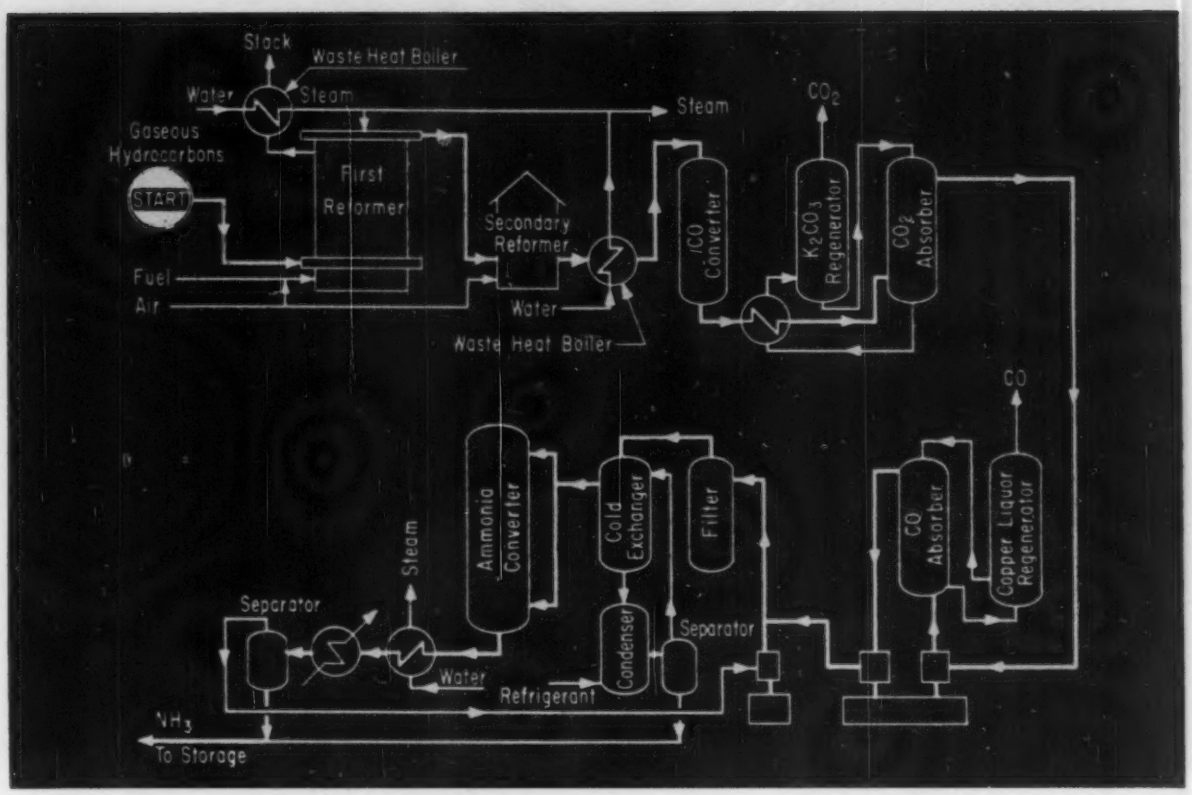
The sulfonic acid is neutralized with 20-50 percent caustic soda solution to a pH of 8 at a temperature of about 125° F. Chemical "builders" such as trisodium phosphate, tetrasodium pyrophosphate, sodium silicate, sodium chloride, sodium sulfate, carboxymethyl cellulose, etc., are added to enhance the detersive, wetting or other properties desired in the finished product. A flaked dried product is obtained by drum drying, or a bead product is obtained by spray drying.

Operating Conditions: Refer to the above text and flow diagram.

Yields: Alkylation, 75 percent; sulfonation, substantially 100 percent; drying, 95 percent or greater.

Commercial Installations: Continental Oil Company, Baltimore, Md., and Chicago; Atlantic Refining Company, Philadelphia, Pa.; Oronite Chemical Company, Richmond, Calif., and Monsanto Chemical Company, St. Louis, Mo.

References: PETROLEUM REFINER, July,'54,p157; *Ind. Eng. Chem.*, **46**, 1925 (1954); *Ind. Eng. Chem.*, **46**, 248 (1954); *J. Am. Oil Chemists' Soc.*, 31, 200 (1954).



Ammonia— CHEMICAL CONSTRUCTION CORPORATION

Application: This is a process for the manufacture of ammonia.

Charge: The feed to the process may be any mixture of gaseous hydrocarbons below hexane consisting primarily of saturates, or acetylene off-gas, or a mixture of hydrocarbons and off-gas.

Description: The feed gases are reformed by reaction with steam at any pressure up to 300 psig. The optimum pressure is selected for the particular gas to be processed. The process steam required is generated in waste heat boilers.

Most of the hydrocarbons are reformed to hydrogen, carbon monoxide and carbon dioxide in the primary reformer. Heat for the reaction is supplied by a fuel such as natural gas or, fuel oil.

The reactions are completed in the secondary reformer. The necessary heat is supplied by reaction of combustible products with oxygen in air. The correct amount of nitrogen to form a 3:1 hydrogen-nitrogen ratio enters with the air.

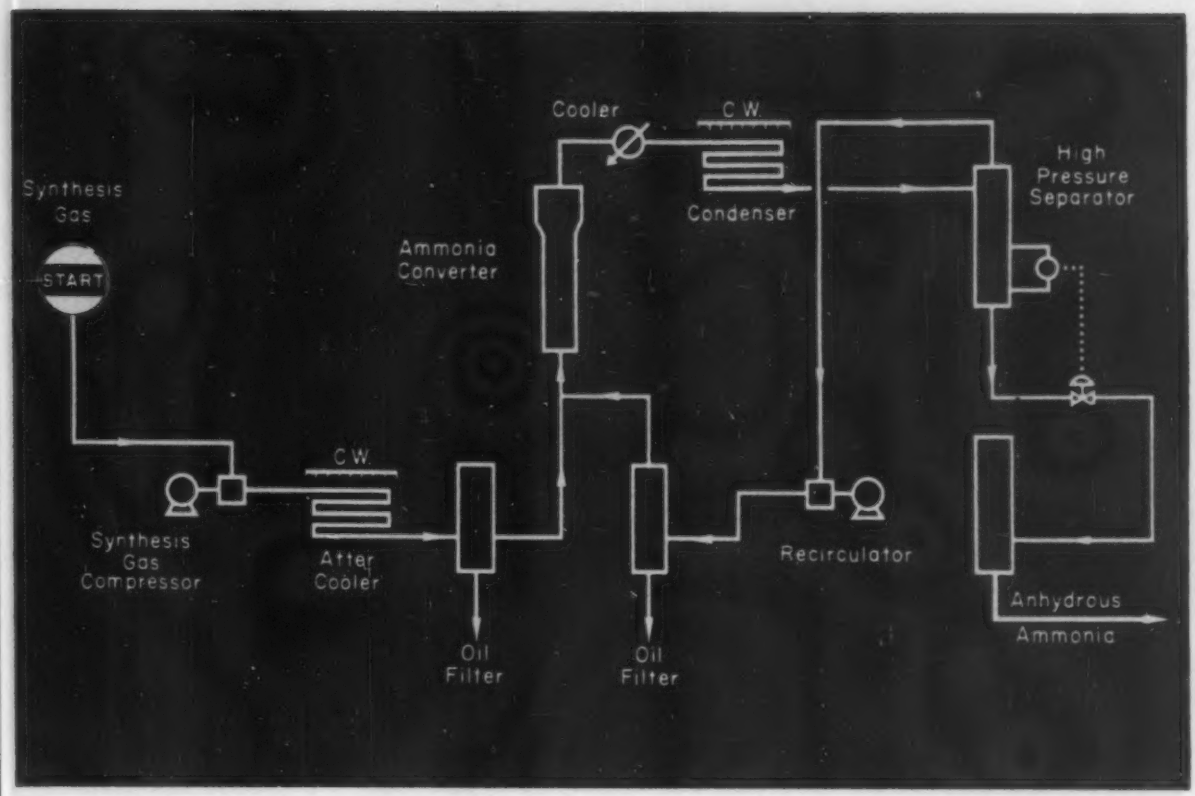
Most of the carbon monoxide formed by reforming is converted to carbon dioxide in the carbon monoxide converter, by reaction of carbon monoxide with steam to form hydrogen and carbon dioxide.

The reformed gas is purified as follows: Carbon dioxide is removed by scrubbing with hot potassium carbonate solution at about 250 psig. If the reforming pressure is below 250 psig the gas passes through one stage of compression before carbon dioxide removal. Residual carbon monoxide is removed by scrubbing with cold copper liquor at 2,000 psig.

After purification the gas is compressed to 5,200 psig and synthesized to ammonia by the well known NEC Process as illustrated in the flow diagram. Production of steam in the synthesis loop is optional depending on economic consideration for a particular plant.

Products: The primary product is anhydrous liquid ammonia with a minimum purity of 99.9 percent. Other products are carbon dioxide and carbon monoxide. The carbon dioxide is of sufficient purity to be used for the production of dry ice or urea. The carbon monoxide may be used as supplemental feed to a methanol plant.

Commercial Installations: There are domestic and foreign installations of the NEC Process for ammonia synthesis in operation all over the world.



Ammonia (Claude Process)—THE FLUOR CORPORATION, LIMITED

Application: A process for the manufacture of anhydrous ammonia.

Charge: Feed to the ammonia synthesis unit is gas containing 75 percent hydrogen and 25 percent nitrogen. Such synthesis gas may be produced from catalytic reformer off-gas, butadiene off-gas, coke oven gas, electrolytic cell hydrogen, or other sources by nitrogen scrubbing. It may also be produced by steam methane reforming or partial oxidation of natural gas or other hydrocarbons.

Product: Liquid anhydrous ammonia of 99.9 percent purity.

Description: Synthesis gas containing 75 percent hydrogen and 25 percent nitrogen flows to the synthesis gas compressors for compression to about 400-600 atmospheres, cooled, passed through a lube oil removal unit, blended with recycle gas, and fed into the Claude Converter. The gases enter the Claude Converter at about 100° F and internal heat exchange increases this temperature to a suitable level for rapid conversion to ammonia. The exothermic reaction raises the temperature level within the converter to about 1100° F, but this heat is transferred to the incoming feed gas so that the gases leave the converter at about 480°-510° F. The effluent gases pass through the tubes of a water-cooled condenser which condenses most of the ammonia produced, allowing a very small fraction to recycle with the unconverted gases. The anhydrous ammonia produced is passed to storage through an automatic let-down valve. Unconverted gases are recompressed and passed through a filter for lube oil removal before passing back to the converter inlet.

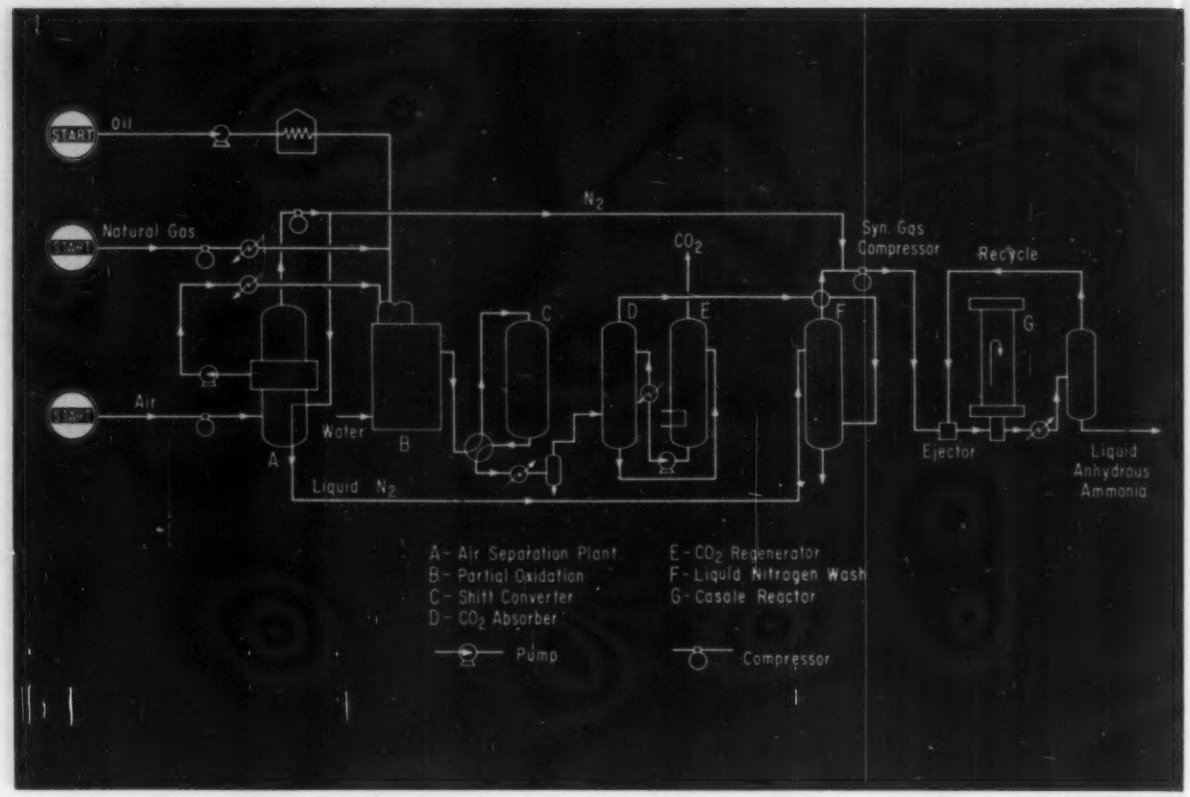
Synthesis gases purified in a liquid nitrogen scrubbing unit are so pure that no vapor purge from the loop is necessary. An equilibrium is established wherein the small quantity of inerts introduced with the syn gas passes from the high pressure separator dissolved in the liquid ammonia as long as inerts in fresh synthesis gas are less than 250 ppm.

Operating Conditions: The synthesis converter starts producing at about 400 atmospheres, and most of the ammonia production is made near that level. The converter is designed to permit operation as high as 600 atmospheres, which will occur after the catalyst has aged.

Yield: About 97 percent based on nitrogen and hydrogen.

Commercial Installations: The Claude converter is in use at Mississippi River Chemical Company, Selma, Missouri; Hercules Powder Company, Pinole, California; Mississippi Chemical Corporation, Yazoo City, Mississippi; San Jacinto Chemical Company, Houston, Texas; Ketona Chemical Company, Ketona, Alabama; and Calumet Nitrogen Products Company at Whiting, Indiana. A plant incorporating the Claude Converter is under construction for Petroleos Mexicanos at Minatitlán, Mexico.

Reference: *Chem. Eng. Progress,* **48,** 468 (1952).



Ammonia— FOSTER WHEELER CORPORATION

Application: A process for manufacturing ammonia.

Charge: Hydrocarbon oil and/or gas, water and air.

Product: Liquid Anhydrous Ammonia.

Description: The processing sequence for the synthesis of ammonia comprises six steps: air fractionation, partial oxidation, shift conversion, carbon dioxide removal, liquid nitrogen wash and ammonia synthesis.

An alternate processing sequence would involve catalytic reaction of steam with hydrocarbon gases (the steam-methane reaction) in place of partial oxidation.

Air, filtered and caustic scrubbed, is compressed to approximately 600 psig, liquefied and separated into nitrogen and oxygen in the air separation plant. The nitrogen is compressed and the bulk of it is used for blending into the purified synthesis gas. A slip stream of this nitrogen re-enters the air plant and is liquefied for use in the liquid nitrogen wash tower. Liquid oxygen is pumped thru a preheater to the Texaco generator.

Preheated hydrocarbon oil/water mixture (or hydrocarbon gas) also enters the generator, mixes with the oxygen and the highly exothermic reaction takes place. The products, mainly carbon monoxide and hydrogen, are quenched with water and enter the shift converter where in the presence of a catalyst, carbon monoxide reacts with steam to form additional hydrogen and carbon dioxide. The effluent from the shift converter passes through a heat exchanger for recovery of process heat, is cooled, flows through a liquid knockout drum and then to the carbon dioxide removal system.

Carbon dioxide is removed by absorption in a suitable medium such as monoethanolamine which is then reactivated by heat, releasing the carbon dioxide to battery limits.

The hydrogen stream then enters the liquid nitrogen wash tower where residual carbon monoxide, methane and argon are removed. The purified hydrogen is blended in specified proportions with nitrogen, produced at the air separation plant, and enters the Casale synthesis system.

The gaseous mixture of hydrogen and nitrogen is compressed to approximately 9,000 psig and enters the reactor, via the jet ejector system which serves to return the uncoverted recycle gases to the reactor. The ammonia synthesis is completed in the presence of a special catalyst.

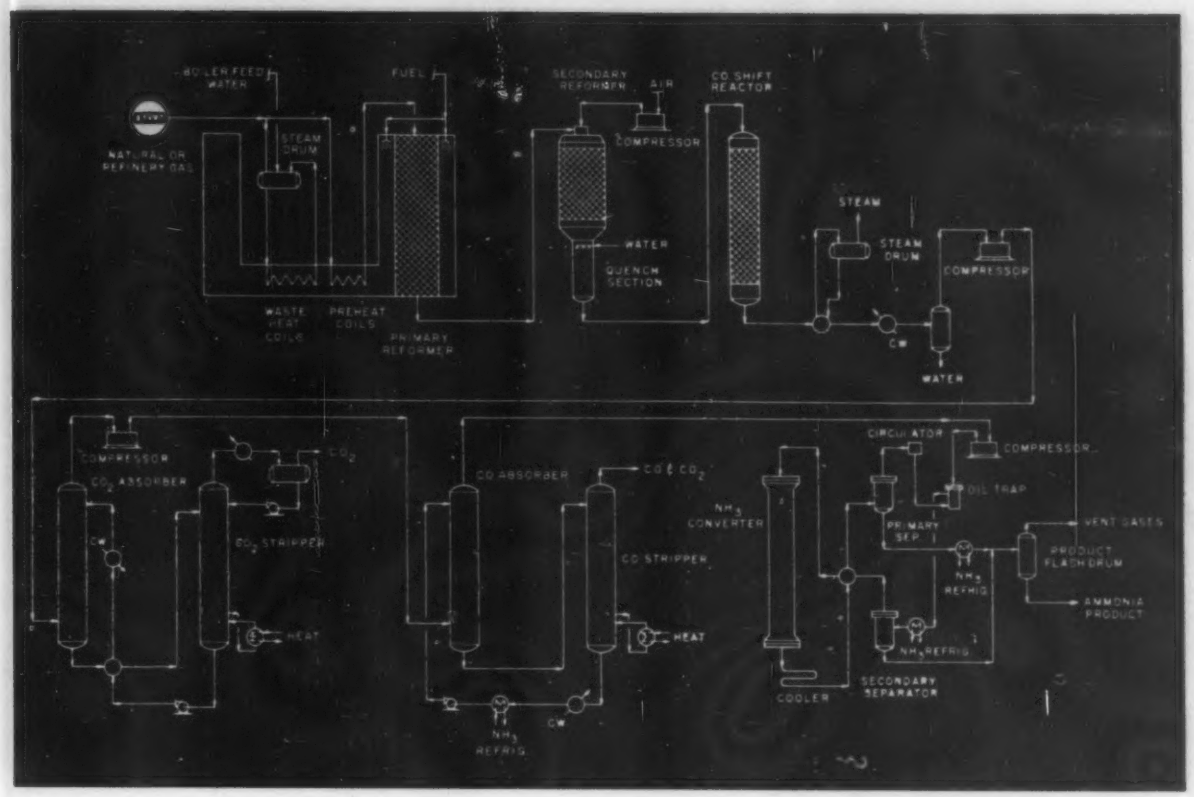
The effluent gases are cooled, the anhydrous ammonia is condensed and separated from the unconverted gases which are returned to the reactor via the ejector system. The liquid anhydrous ammonia flows to storage.

The ejector system eliminates the necessity for a recirculating compressor for the unconverted gases.

Operating Conditions: Important operating conditions are mentioned in the above description.

Commercial Installations: Over 2000 tons per day of installed capacity.

References: PETROLEUM REFINER, Sept.'53,p178; CHEMICAL ENGINEERING, May'54,p332.



Ammonia— THE M. W. KELLOGG COMPANY

Application: A high pressure steam methane reforming process for ammonia production.

Charge: Natural gas, refinery gas, coke oven gas or light hydrocarbons and air.

Product: High purity ammonia.

Description: The steam methane reforming process produces ammonia by steam reforming natural or refinery gas under pressure, followed by carbon monoxide shift, purification of raw, synethsis gas and ammonia synthesis.

In the process, saturated and unsaturated hydrocarbons are decomposed by steam according to the basic equation:

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

It is normally advantageous with starting materials having a wide range of methane concentration (e.g., natural gas, refinery gases and coke oven gas, and other light hydrocarbons). Feed streams high in olefins or sulfur require pretreatment.

In the first step, the primary reformer converts about 70 percent of a natural gas feed into raw synethsis gas, in the presence of steam using a nickel catalyst.

Primary reformer effluent is then charged to a secondary reformer where air is introduced to supply the nitrogen required for ammonia. The heat of combustion of the partially reformed gas supplies the energy to reform the remainder of the gas after reacting with the oxygen in the air.

The high pressure reforming process utilizes the potential energy of the relatively high pressures at which natural gas normally is available. Although the synthesis gas must be still further compressed before charging to the ammonia converter, high pressure reforming conserves 30-40 percent in compressor horsepower over usual practices giving low pressure synthesis gases.

After leaving the secondary reformer, the mixture is quenched and sent to the shift converter. In the shift reaction, carbon monoxide in the gas streams is converted to carbon dioxide, and simultaneously makes hydrogen (a result of the reaction with steam).

Shift reactor effluent, after heat recovery, is cooled and compressed, then goes to the gas purification section. Carbon dioxide is removed from the synthesis gas in a regenerative MEA (monoethanolamine) or other standard recovery system.

After carbon dioxide removal, carbon monoxide traces left in the gas stream are removed by scrubbing with a regenerative cuprous ammonium acetate solution.

The resulting pure synthesis gas passes to the oil separator, where it mixes with a recycle stream cooled with ammonia refrigeration, and goes to the secondary separator where anhydrous ammonia (contained in the recycle stream) drops out.

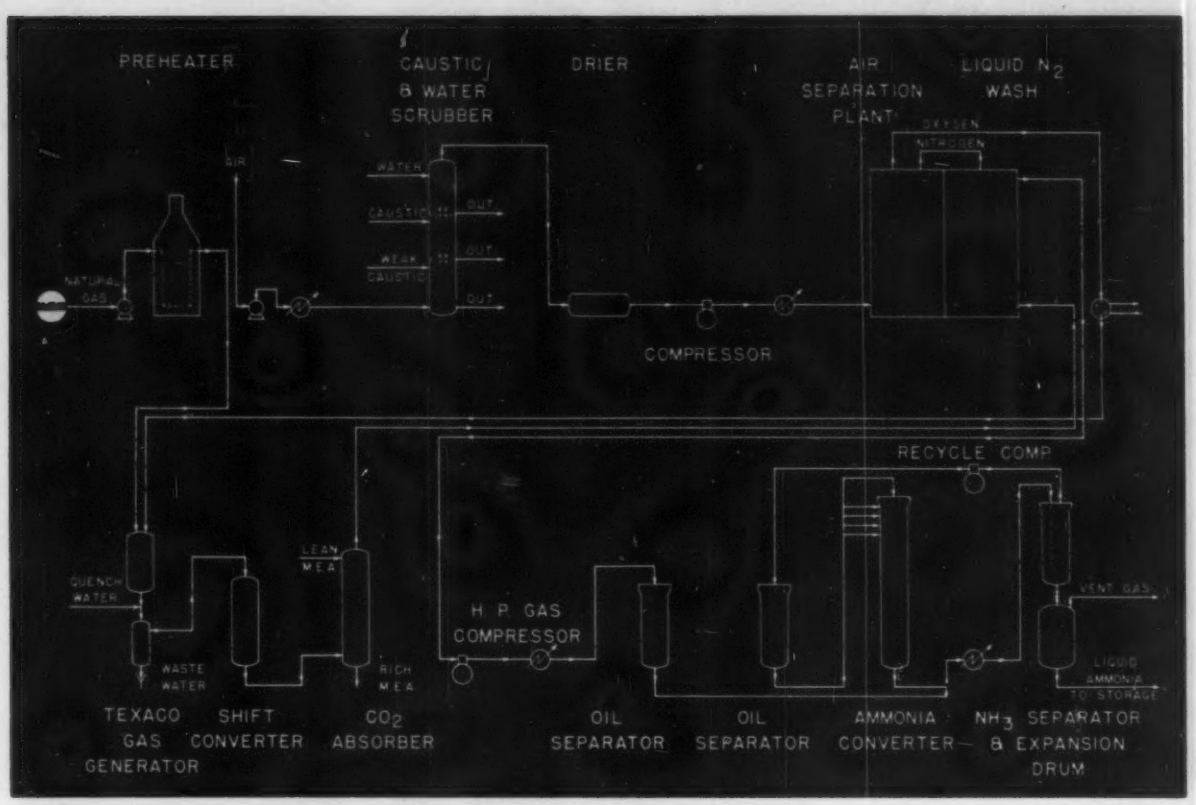
Synthesis gas is then passed through heat exchange and charged to the catalytic ammonia converter. Product gas from the converter is cooled and exchanged against converter feed gas.

Anhydrous liquid ammonia then separates out in the primary separator and, after further cooling, goes to the anhydrous ammonia product flash drum.

Operating Conditions: The feed to the reforming section is normally in the order of 200 psig. Temperatures in primary and secondary reformers are 1,400-1,800° F., while shift reaction temperatures are 700-850° F.

Ammonia synthesis is normally at 4,700 psig. The "quench-type" ammonia converter was developed by Kellogg. Temperature is accurately and flexibly controlled inside the catalyst mass to allow a catalyst basket temperature gradient giving a maximum yield of ammonia per pass, regardless of production rate. Hot spots, common in catalyst baskets having tubular heat exchangers, and a cause of catalyst activity deterioration, are eliminated by the reactor's approach to isothermal conditions.

Commercial Installations: This process is in production at five plants with a sixth being brought on stream shortly. Total production is rated at over 1,000 tons per day.



Ammonia (Uhde)— ARTHUR G. McKEE & COMPANY

Application: A process for manufacture of anhydrous ammonia.

Charge: Natural gas, ethane, LPG, any light hydrocarbon, residual oils, catalytic reformer tail gas, coke oven gas, coal.

Description: Raw synthesis gas is produced either by partial combustion of a hydrocarbon or by the steam-methane reforming process. Whereas the steam-methane reforming process is suitable for use only with natural gas and light hydrocarbons, the partial combustion process may be used to produce synthesis gas from any hydrocarbon or solid carbonaceous material.

The above flow diagram of the ammonia process illustrates a typical partial combustion system employing a Texaco gas generator, described elsewhere in this handbook.

The partial combustion process uses oxygen of 95 percent purity or higher obtained from an air separation unit which also produces a high purity nitrogen stream. In the steam-methane reforming process, air is used instead of oxygen and air separation facilities are not employed.

The raw synthesis gas consists primarily of hydrogen, carbon monoxide, a lesser carbon dioxide quantity and small amounts of argon and methane. Hydrogen sulfide may also be present depending upon the feed material.

The raw synthesis gas is reacted with steam in the presence of a catalyst so that the carbon monoxide is converted to carbon dioxide and additional hydrogen is produced.

Various scrubbing processes are available for removal of the carbon dioxide from the synthesis gas. Residual carbon monoxide may be removed by liquid nitrogen scrubbing. However, complete carbon dioxide removal is necessary in this case and MEA scrubbing must be followed by caustic scrubbing and drying before the gas is fed to the nitrogen scrubbing unit.

After purification, drying and adjustment of the hydrogen to nitrogen ratio, the ammonia synthesis gas is compressed to a pressure of 6,400 psig. The oil is carefully removed before the stream enters the converter circuit. The entry point is immediately upstream of the ammonia condenser. As the ammonia condenses it dissolves the traces of impurities and removes them from the system.

In the Uhde converter the catalyst is arranged in a number of individual beds. Cold gas, which has bypassed the internal heat exchanger, is introduced between the beds as individually controlled quench streams. In detail, the gas flow through the converter is as follows: Total converter feed, less quench, enters at the top of the converter and flows down through the annulus between the converter shell and the internal assembly. The gas then flows outside the tubes of the heat exchanger located in the lower part of the converter, and is heated to reaction temperature. A centrally located tube, containing the startup heater, directs the heated gases back to the top of the converter, where its flow is again reversed, and it is fed to the top catalyst bed. The reacted gas leaving the bottom catalyst bed is cooled in passing through the tubes of the heat exchanger.

The converter internal assembly (of hydrogen-resistant steel) is of simple design and requires minimum maintenance. A catalyst change can be effected without removal of the internals. It is not necessary to provide the customary heavy cranes to lift the internal assembly, or as in many cases, the complete converter. Uhde has developed a trunion arrangement so that the converter may be pivoted into a horizontal position.

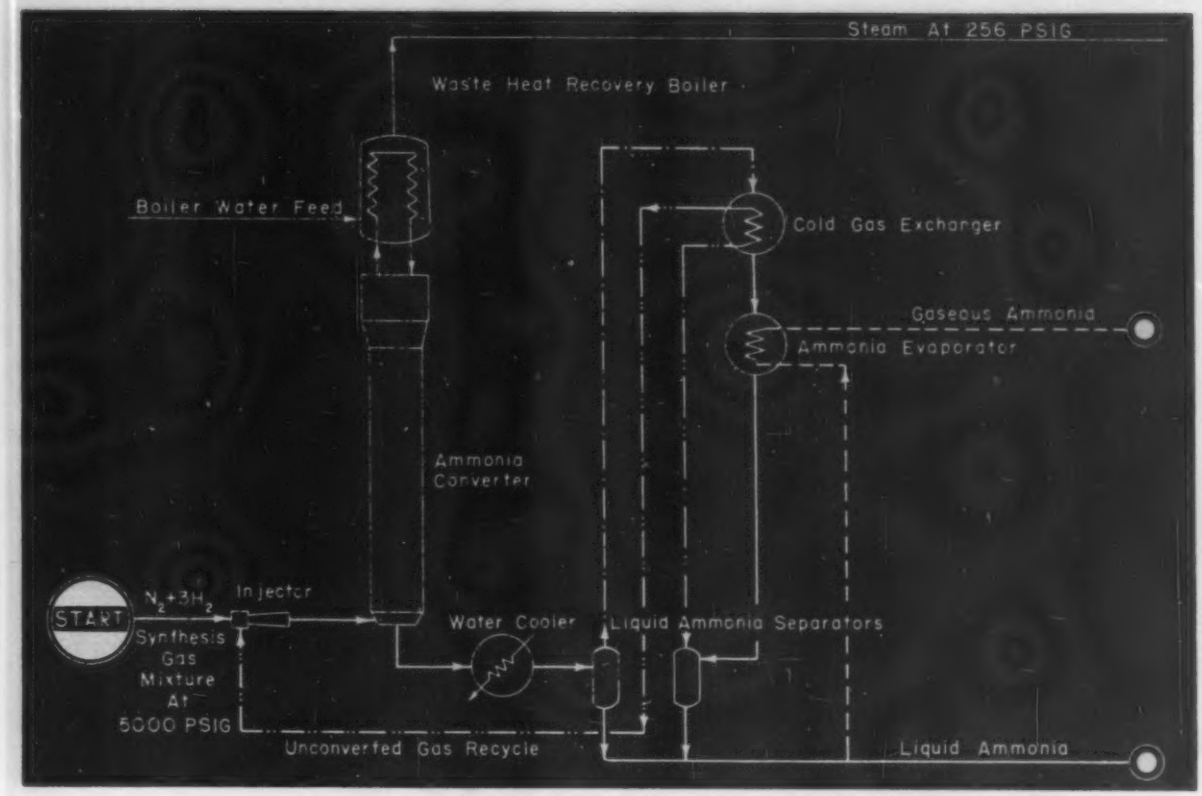
The gas from the discharge of the converter is passed through a water cooled heat exchanger and into the ammonia separator where the condensed ammonia is withdrawn. The unconverted gas is returned to the converter by the recycle compressor.

The condensed ammonia from the separator is depressured to the expansion drum. The gas evolved is vented to a fuel line. The liquid ammonia is taken to storage.

Operating Conditions: The ammonia converter normally operates at 6,400 psig. At this pressure no refrigeration system is required for condensation of the ammonia. Where conditions make it desirable the pressure may be reduced to 4,600 psig. At the lower pressure the ammonia condenser is cooled by a mechanical refrigeration system or by re-evaporation of condensed ammonia. The latter method is of interest for plants which are to produce the bulk of the product as gaseous ammonia.

The internal temperature of the converter is maintained low enough so that expensive materials of construction are not required. The catalyst is not expensive and is readily available.

Commercial Installations: Uhde has installed over 40 synthesis plants in recent years. Among the latest are Farbwerke Hoeschst A.G. near Frankfurt, Germany, Typpi Oy at Oulu, Finland, and Bergwerksgesellschaft Hibernia A.G. at Wanne-Eickel, Germany.



Ammonia— MONTECATINI

Application: Synthesis of ammonia by the Fauser-Montecatini processing technique.

Charge: It is essential to have a pure $N_2 + 3H_2$ synthesis gas mixture, compressed at about 5000 psig. Hydrogen contained in said mixture can be obtained by several methods and should be chosen according to the most favorable local conditions.

Product: Pure ammonia, partially available in the liquid form and partially in gaseous form. High-pressure steam is also obtained.

Description: Fresh synthesis gas mixture, before entering the converter, acts as a mechanical compelling medium for recycling the unreacted gases in a special, highly efficient injector. The converter, designed according to the up-to-date Fauser-Montecatini patented type, operates at a pressure of 4,260 psig and is equipped with a highly effective system for recovering the reaction heat.

Thus the temperature of the different catalyst sections can be carefully controlled so as to obtain from the catalyst itself the best performance, thus increasing conversion efficiency and preventing dangerous super-heating.

The catalyst temperature control is achieved by circulating distilled water in a set of various heat exchangers placed at different levels in the catalytic mass. The waste heat recovery produces steam having the remarkable pressure of 250 psig.

As a result of such careful temperature control, gases leaving the converter have an average ammonia content of 20 percent. This is exceptionally high considering the rather low synthesis pressure.

Ammonia is condensed down at approx. —13° F in three stages: first in a water spray cooler, then in a cold gas exchanger and finally in an ammonia evaporating cooler.

The condensed ammonia is removed from the cycle and expanded in a storage tank. From here it is bypassed to the ammonia cooler where it performs a cooling effect by evaporating part of ammonia at about atmospheric pressure.

After removal of the condensed ammonia the unreacted cold gases flow through the exchanger and are then recycled to the converter by means of the injector.

Several main advantages are offered by this improved process and can be summarized as follows:

The synthesis pressure chosen for this process permits safe and efficient operation of the unit together with low maintenance and operative costs.

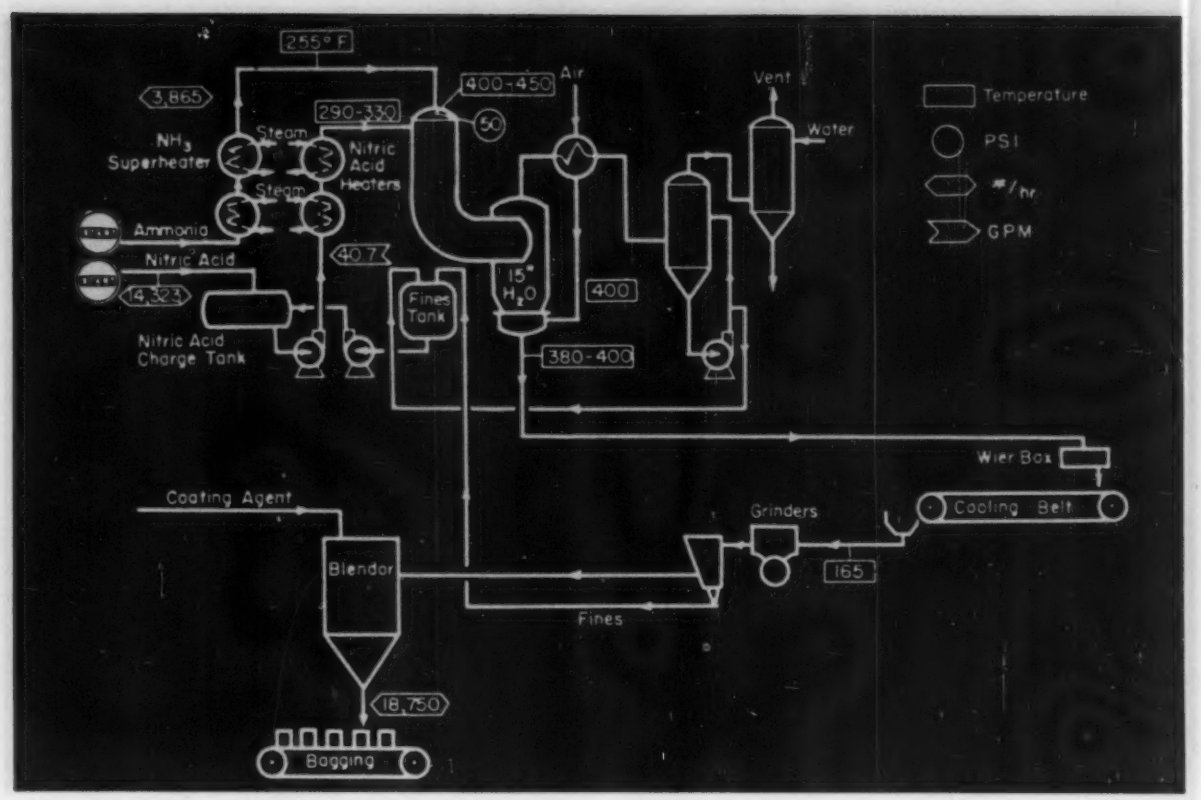
The temperature control in the catalyst layers permits high conversion, long catalyst life and makes possible the recovery of 0.85 ton of steam per ton of ammonia produced. This is an important economic factor.

The high efficiency of the injector adopted offers, in comparison with a mechanical circulator, several advantages including low cost, no maintenance, no oil entrainments (this means best operating conditions for the catalyst), power consumption comparable to that of mechanical circulators.

Operating Conditions: The main operative conditions are given in the above description. The temperature in the converter is kept at about 900° F.

Yields: For the production of 1,000 kg of ammonia, 2,750 N cu. meters of N_2+3H_2 synthesis gas mixture, compressed at 5,000 psig are required. For the same amount of produced ammonia, 850 kg of high-pressure steam are recovered.

Commercial Installations: 57 ammonia plants have been erected throughout the world utilizing the Fauser-Montecatini processes, accounting for more than 2,200,000 tons per year of ammonia capacity.



Ammonium Nitrate (Stengel Process)—COMMERCIAL SOLVENTS CORP.

Application: A process for manufacturing fertilizer grade ammonium nitrate.

Charge: Anhydrous ammonia and nitric acid.

Product: Flaked ammonium nitrate.

Description: The Stengel process produces molten or dissolved ammonium nitrate of any desired concentration. No further concentration or evaporation is required for either prilling, graining or flaking. The process is not dangerous as there is no large amount of molten ammonium nitrate in the reactor at any one time and this is blanketed with steam until it enters the weir box.

Liquid anhydrous ammonia is vaporized and superheated to 225° F. and introduced along with nitric acid (containing ammonium nitrate fines, dissolved) at 290-330° F. into the top of the packed reactor. The reaction proceeds as follows:

$$NH_3 + HNO_3 \rightarrow NH_4NO_3 + 20{,}600 \text{ cal.}$$

This reaction product passes to a separator where heated air is introduced to reduce the water content and then molten ammonium nitrate is removed from the bottom. Before the air is introduced to the reactor it is heated to 400° F. by exchange with the separator overhead product and then introduced into the reactor in two different places. This air is blown up through the molten salt and carries with it water vapor. This process reduces the water content of the molten ammonium nitrate from about 2 percent to less than 0.2 percent. This air must be free from any oil or other carbonaceous matter since these materials make ammonium nitrate more susceptible to explosion.

The air leaving the stripper carries with it a small amount of entrained ammonium nitrate. To remove this, the air is scrubbed in a partial condenser to remove the ammonium nitrate and traces of ammonia. The concentrated liquor obtained from this scrubbing is recycled back to be used as solvent in the fines dissolving tank. The rate of recirculation of condensate in the partial condenser is controlled by the specific gravity of the concentrated liquor. The overhead from the partial condenser is scrubbed with water before venting to the atmosphere.

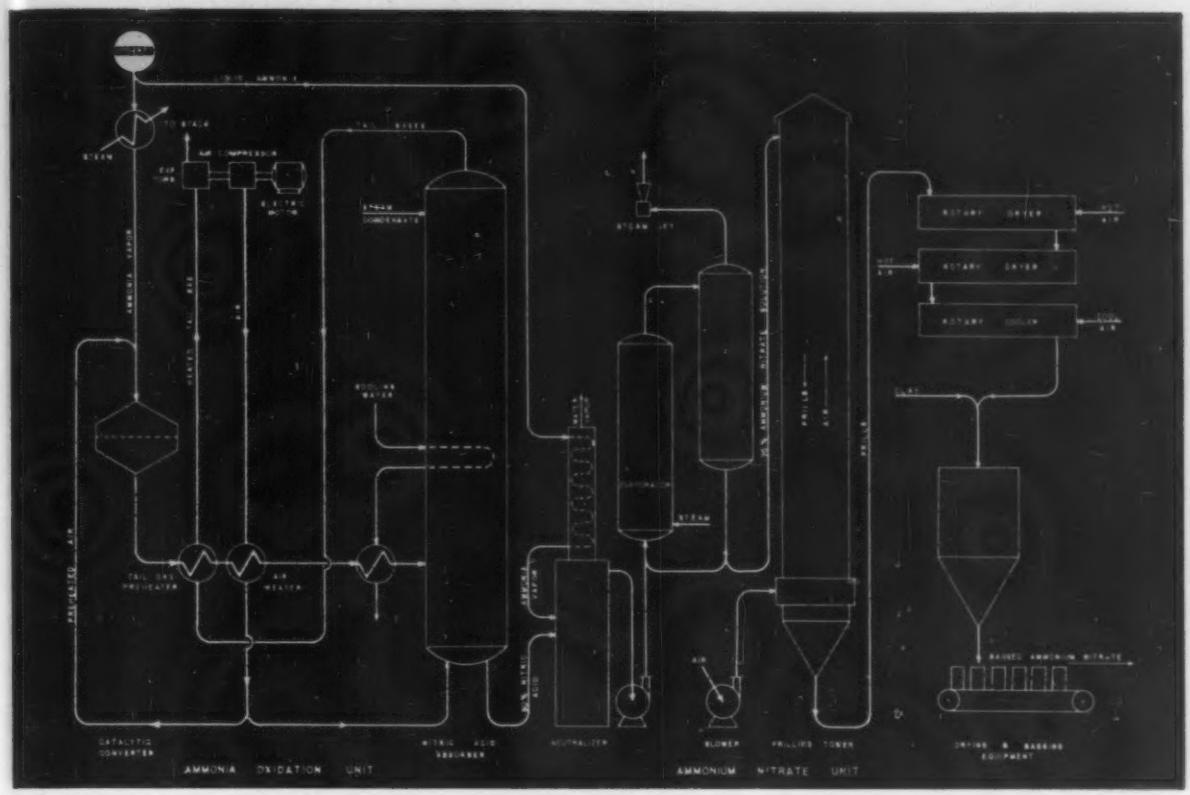
The molten ammonium nitrate product flows to a weir box and onto stainless steel cooling belts. The belts move over water and the molten ammonium nitrate solidifies. At the end of each belt the flake is broken up and goes to grinders and sizing equipment. The fines return to the nitric acid mixing tank.

The final product is coated with 3 pounds of diatomaceous earth for each 97 pounds of ammonium nitrate.

Yields: The over-all ammonia to ammonium nitrate is 100 percent.

Commercial Installations: Commercial Solvents Corporation, Sterlington, La.

References: Industrial and Engineering Chemistry, Vol. 46,Apr.'54,p622.



Ammonium Nitrate and Nitric Acid— GIRDLER CONSTRUCTION DIV., CHEMETRON CORPORATION

Application: A process for manufacturing nitric acid and fertilizer grade ammonium nitrate.

Charge: Anhydrous liquid ammonia.

Product: 55 percent to 60 percent nitric acid and prilled ammonium nitrate with a nitrogen content of 33.5 weight percent.

Description: First, ammonia is oxidized with air to produce oxides of nitrogen which are then absorbed in water to form nitric acid. The reactions may be written as follows:

$$4\,NH_3 + 5\,O_2 = 4\,NO + 6\,H_2O$$
$$2\,NO + O_2 = 2\,NO_2$$
$$3\,NO_2 + H_2O = 2\,HNO_3 + NO$$

Ammonium nitrate is then formed by the reaction of nitric acid with ammonia as follows:

$$NH_3 + HNO_3 = NH_4NO_3$$

The DuPont pressure ammonia oxidation process is shown. Anhydrous liquid ammonia is first vaporized and then mixed with clean, compressed air and passed over a platinum gauze catalyst at 100-psig pressure. This catalyst is contained in the converter and, as the reaction is highly exothermic, requires water cooling.

The hot gas emerging from the converter is cooled by heat exchange. The cooled gas then goes to an absorber tower where steam condensate is used for absorption. A secondary oxidation reaction occurs in the tower with the bleaching air which is introduced to the absorber. The nitric acid produced passes through the bleach tray where oxides of nitrogen are stripped from the acid.

In the production of ammonium nitrate, the ammonia, as a vapor, and nitric acid streams are metered and controlled individually to give as close neutralization as possible. Under normal operation a solution of 83 to 85 percent ammonium nitrate may be attained by allowing the heat of reaction to evaporate the excess water. The solution then goes to a storage tank.

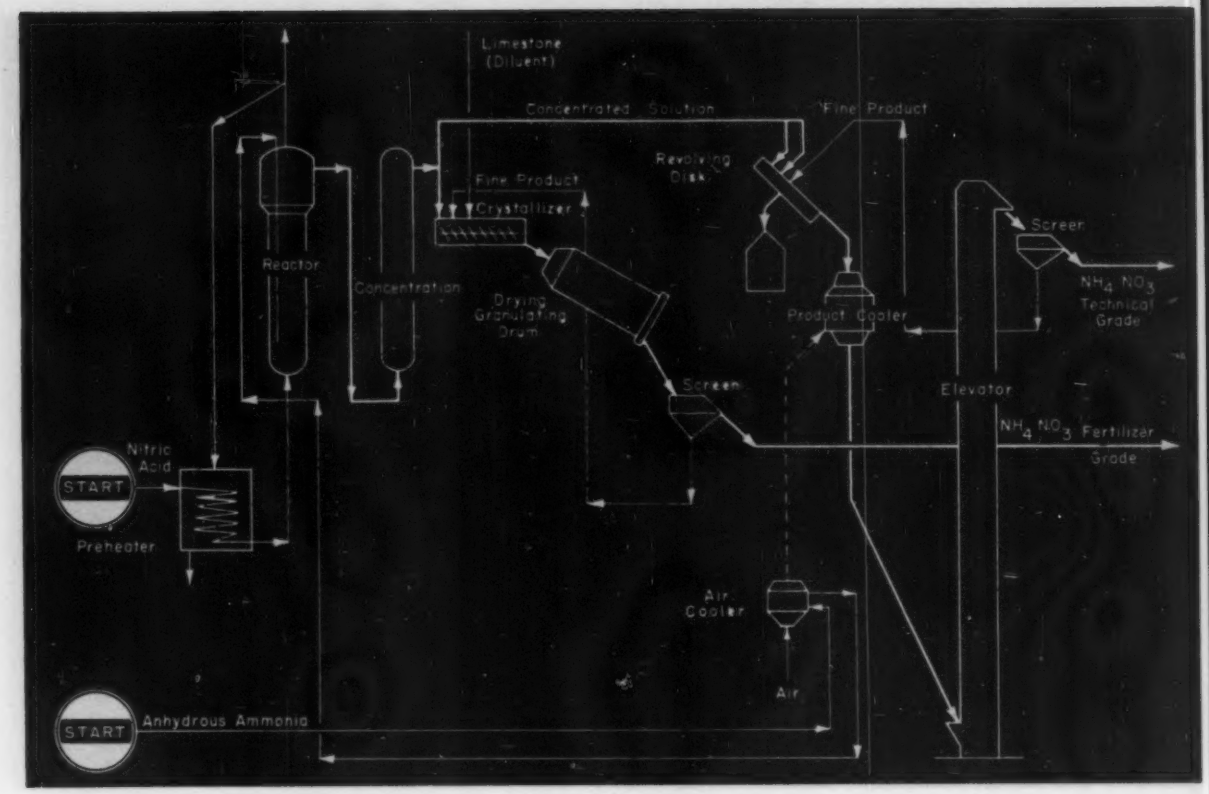
Before solidification the solution is pumped to a vacuum evaporator where it is concentrated to about 95 percent ammonium nitrate. The prilling process of solidification is that of Canadian Patents and Development, Ltd. The 95 percent solution is pumped to the top of the prilling tower and sprayed countercurrent to an updraft of air. The free fall distance in the tower is greater than 100 feet. A wet granular salt is formed. Little or no moisture is lost in this process and the salt still has about 5 percent water.

The wet salt is dried in rotary kiln-type dryers. The salt then passes through a cooler using unheated air. At this point the moisture content is about 0.1 percent. The ammonium nitrate is mixed with four weight percent clay to prevent caking during storage.

Yields: The over-all yield of ammonia to ammonium nitrate is about 95 percent. This amounts to about 2.25 tons fertilizer per ton ammonia feed.

Commercial Installations: Mississippi Chemical Company, Cooperative Farm Chemicals Association, Southern Nitrogen Co.

References: *Industrial and Engineering Chemistry,* Vol 23,p860 (1931); Encyclopedia of Chem. Tech., Vol. 9. 333-5 (1952); Industrial & Engineering Chemistry, Vol. 45, No. 3,p496 March (1953).



Ammonium Nitrate— MONTECATINI

Application: A process is described for the manufacture of solid ammonium nitrate either for use as a fertilizer or for technical purposes.

Charge: Nitric acid of 53 percent by weight and pure gaseous ammonia. For adjusting final nitrogen contents in various grades of product, diluents such as limestone and the like are added in the desired amount.

Product: Pure ammonium nitrate containing 34.5 percent of N_2 for technical uses or fertilizer grade product having various nitrogen contents ranging from 20 to 26 percent.

Description: Nitric acid and ammonia are reacted together in liquid phase at a temperature not higher than 293° F (melting point of NH_4NO_3) at atmospheric pressure. Ammonia gas enters the saturator at slight pressure (7-11 psi) and the reaction heat is recovered as steam. The steam is used in subsequent one-stage concentrator where the product solution is concentrated to 93-98 percent, suitable for obtaining the final solid product. Concentration can be carried out following two systems: vacuum concentration or at atmospheric pressure with the help of a hot air stream. In the latter case the solution is kept at a temperature below its boiling point.

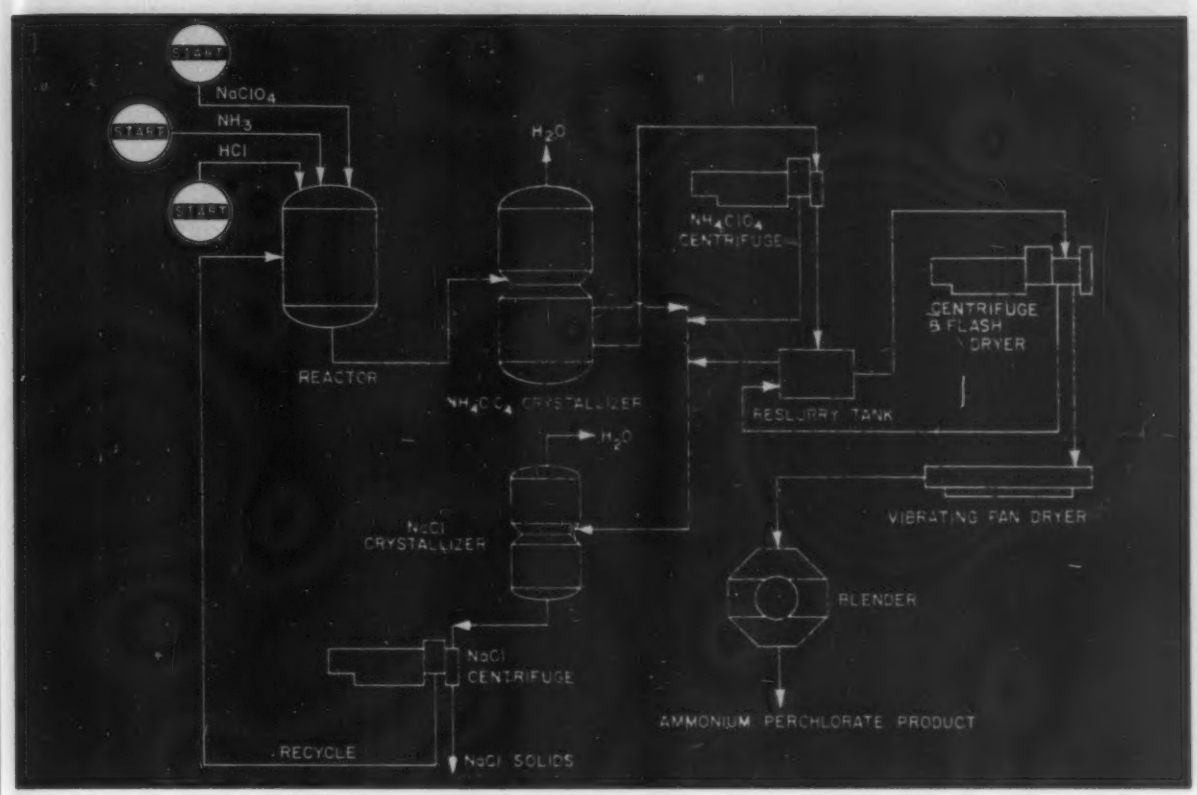
The next step is granulation which enables to obtain from the concentrated solution, the product in solid form. Granulation also can be achieved by means of two different systems, namely; by means of a screw-mixer and a drying-granulating drum, the unit being completed by accessory equipment such as screens, conveyors, elevators etc. The second system mainly consists of a rotating inclined plate on which the hot solution is sprayed; also in this case auxiliary equipment completes the unit, such as a cooler, vibrating screens, powders recovery devices, conveyors etc.

In both cases the product obtained is of superior quality, free-flowing and non-caking and can be stored in bulk quantities for long periods of time.

Operating Conditions: The fundamental operating conditions are those mentioned in the above description.

Commercial Installations: 34 Plants in 12 different countries, have been constructed by Montecatini for the production of ammonium nitrate using this process accounting for 1,340,000 metric tons per year capacity.

Reference: Chem. & Engineering News, March 30, 1959.



Ammonium Perchlorate— AMERICAN POTASH & CHEMICAL CORP.

Application: A process for manufacturing ammonium perchlorate.*

Charge: Sodium perchlorate solution, anhydrous ammonia, and aqueous hydrochloric acid.

Product: Crystalline ammonium perchlorate of 99.5 percent purity.

Description: Ammonium perchlorate is produced by simultaneously and continuously reacting sodium perchlorate solution, ammonia, and 35 percent hydrochloric acid in a recycled aqueous solution. The reaction takes place at a pH of 5.5 in a glass-lined, jacketed, mechanically agitated vessel having a 20-minute retention time. An operating temperature in the range of 160-180° F is controlled by mixing steam and water in the vessel jacket. Reactant flows are ratio controlled in equimolar proportions.

The discharge from the reactor is continuously monitored for pH and is adjusted as required through addition of ammonia as it advances to the amonium perchlorate crystallizer. This vacuum-cooled crystallizer, of Type 316 stainless steel, is operated continuously, cooling the reactor effluent from the reactor temperature to 95° F. The feed liquor is mixed continuously with a large amount of circulating mother liquor and the resulting mixture is passed into a vaporizer, where the solution supersaturates. The solution then flows upward through a dense bed of crystals, relieving its supersaturation on the crystal suspension. A slurry containing the desired size distribution is removed continuously.

This slurry is fed to the ammonium perchlorate centrifuge where mother liquor is removed and the crystals are washed. The washed crystals are discharged directly into a reslurry tank of saturated ammonium perchlorate solution. This saturated solution serves to reduce the chloride concentration of the solids and as a transfer medium for the ammonium perchlorate to the drying operation located some distance away.

The perchlorate is recovered from this reslurry tank by centrifuging a slurry containing about 25 percent perchlorate in crystal form and about 19 percent in solution. Mother liquor is recycled while a flash dryer centrifuge reduces the moisture content of the crystals to about 0.5 percent. The partially dried crystals go to a three-stage vibrating pan dryer from which they emerge for packaging with a moisture content less than 0.02 percent. The dried crystals are passed over a double-deck screen for removing oversize and undersize material. These rejects are returned to the reactor to be recrystallized.

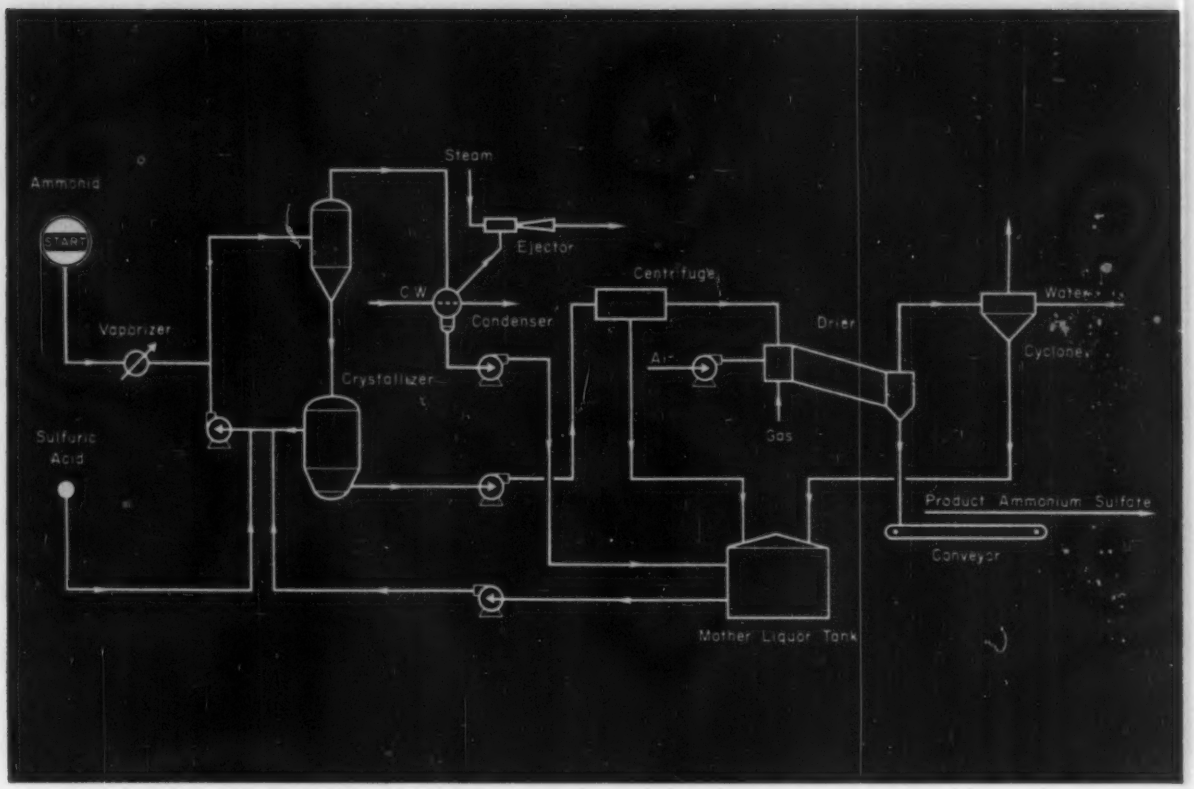
Wash water, mother liquor, and crystallizer overflow are collected from the ammonium perchlorate centrifuge and pumped to the sodium chloride crystallizer. Concentration of the mother liquor is accomplished by removing the sodium chloride slurry from the crystallizer to a centrifuge. From this centrifuge the solids are dissolved and pumped to waste. The wash water and mother liquor from the centrifuge are mixed in a surge tank with the crystallizer overflow and pumped to the reactor system as recycle. Loss of mother liquor with the sodium chloride solids discharged at this point can lower the over-all chemical efficiency. The washed sodium chloride discharged from the continuous centrifuge contains less than 0.1 percent ammonium perchlorate.

Operating Conditions: Reactant ratios, temperatures and pH are the important operating variables. The product must be dried at a moderate temperature since decomposition starts at 400° F.

Yields: Yields based on ammonia and perchlorate ion approximate 96 percent.

Commercial Installations: Ammonium perchlorate is produced according to this process by the American Potash & Chemical Corporation at Henderson, Nev. Other producers are Pennsalt Chemicals Corporation at Portland, Ore., and H.E.F., Inc. at Columbus, Miss.

References: *Chemical Engineering*, December, 1955; Joseph C. Schumacher (to American Potash & Chemical Corporation) U.S. 2,739,873 (March 27, 1956)*; *Chemical Engineering Progress*, September, 1957.



Ammonium Sulfate— THE FLUOR CORPORATION, LTD.

Application: Process for manufacture of crystalline ammonium sulfate of high quality.

Charge: Ammonia vapor or liquid anhydrous ammonia and sulfuric acid. The ammonia vapor may be in the form of ammonia bearing gases from other processes, or it may be commercial grades of ammonia. Sulfuric acid may be virgin 98 percent acid or, by proper modifications, sulfuric acid-oil sludge or spent sulfuric acid from other processes may be used.

Product: The product is free-flowing crystalline ammonium sulfate of the following composition:

Free Nitrogen	21.00% Minimum
Free Acid	0.05% Maximum
Water	0.05% Maximum

Crystal size depends on size of equipment selected, but typically runs:

60% on +16 mesh
95% on +30 mesh
100% on —30 mesh

If sulfuric acid-oil sludge is used as feed stock, recovered oil will also be one of the products.

Description: This process involves a few simple steps which may be described as follows: (1) Sulfuric acid and ammonia are reacted in the presence of water forming a solution of ammonium sulfate; (2) ammonium sulfate solution is concentrated under controlled conditions to produce the desired crystal size; (3) the crystal slurry is pumped into a centrifuge for dewatering and washing; (4) dewatered crystals are dehydrated and transferred to storage or bagging facilities.

As indicated on the schematic flow sketch, sulfuric acid is mixed with recovered mother liquor and vaporized ammonia to form ammonium sulfate solution. This solution discharges into a suitable crystallizer which operates at reduced pressure. Either a circulating liquor, or circulating magma type crystallizer may be used to perform this step. With either type, conditions of circulation rate, temperature and pH are controlled to produce crystals of the desired shape and size. Small quantities of materials may be added to the crystallizer to aid in forming crystals of the desired characteristics.

The crystal slurry is transferred to a centrifuge for washing and dewatering. Sufficient crystal washing is performed to reduce the free acid to less than 0.05 percent. The dewatered crystals are dried in a gas fired drier to a water content of 0.05 percent or less.

Additional agents for preventing caking may be added to the salt as it leaves the drier. Under most storage and shipping conditions it is possible to obtain a free-flowing material by obtaining large stubby hard crystals dried to less than 0.05 percent water without the use of other agents in the crystallizer and without adding special agents to the dry salt.

Liquor recovered from the fume recovery cyclone, centrifuge and crystallizer condenser is recovered in a mother liquor tank for recycle through the process. This tank also permits washout of equipment and storage of solutions for maintenance and inspection. Sufficient water vapor is lost out the drier and steam ejector to balance the water introduced into the process.

When using certain types of acid sludge or spent acid, it is necessary to provide a separate reactor.

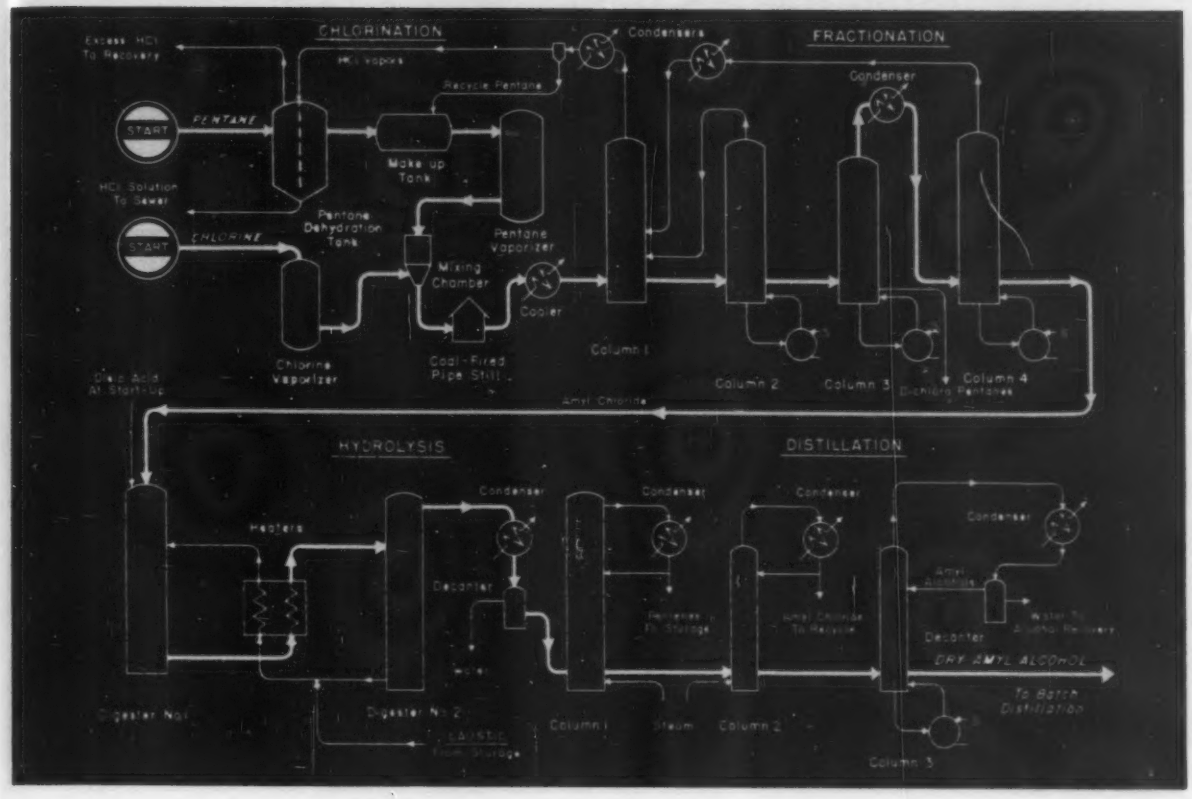
Operating Conditions: Typical operating conditions when using virgin acid and anhydrous ammonia are as follows:

Crystallizer—pressure	5 PSIG
—Temperature	175°F
Vapor Ammonia Feed	100°F—60PSIG
98% H_2SO_4	100°F
pH in Crystallizer	3.5
Crystals from Centrifuge	2% moisture

Yields: The yield of ammonium sulfate is about 98 percent on the basis of sulfuric acid and about 99.9+ percent on the basis of ammonia.

Commercial Installations: There are numerous installations utilizing this process. Two examples are: General Petroleum, Torrance, Calif., and B. F. Goodrich Chemical Company, Calvert City, Ky.

Reference: PETROLEUM REFINER, Nov.'52,p123.



Amyl Alcohol—PENNSALT CHEMICALS CORPORATION

Application: Continuous process for the manufacture of amyl alcohols.

Charge: Pentane, chlorine, caustic soda.

Product: Various grades of mixed amyl alcohols, including primary, secondary, and tertiary isomers.

Description: Pentane is dehydrated by contacting with anhydrous hydrogen chloride, which is a by-product of the chlorination step. The anhydrous pentane and chlorine are vaporized separately, and then mixed in such proportions that the mixture is not in the explosive range. This mixture, at a temperature of about 120° C. then goes to a pipe still where the chlorination reaction takes place. The reactants leave the pipe still at about 300° C. and are immediately sent to a cooler to suppress the formation of dichloropentanes.

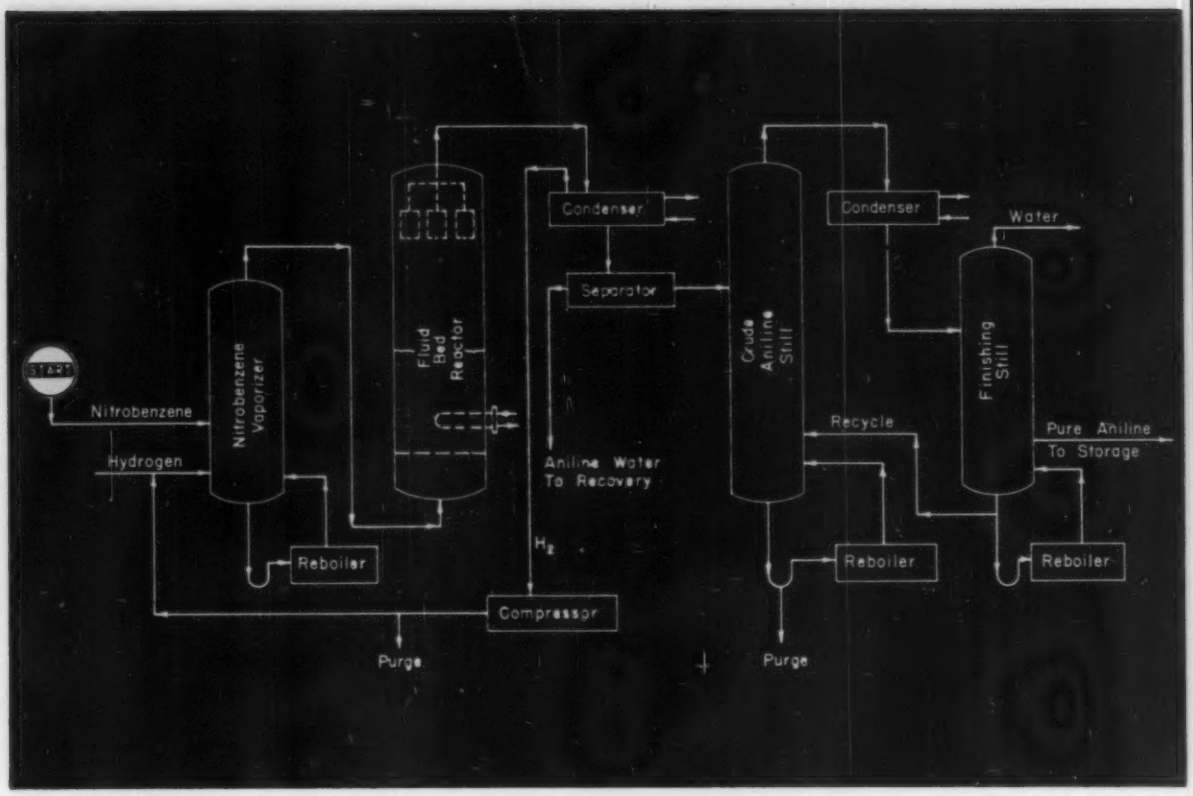
From the cooler the reaction mixture enters a fractionating column in which hydrogen chloride and pentane are removed overhead. The pentane is condensed and returned to the make-up tank. The hydrogen chloride is sent to the pentane dehydration tank where part of it reacts with the water in the pentane to form hydrochloric acid; the acid separates from the pentane and is periodically drained off to the sewer. The unreacted hydrogen chloride passes from the pentane dehydration tank to the recovery unit, where it is dissolved in water to form a commercial grade of hydrochloric acid.

The bottoms from the first column, consisting of amyl chloride, dichlorides, and some pentane, go to a second column, where the pentane is taken off overhead and recycled to the first column. The bottoms from the second column are sent to a third column where amyl chloride is taken off overhead, and dichloropentanes are removed as the bottom product. The amyl chloride then goes to a fourth column in which residual amounts of pentane are removed, and recycled to the first column.

The amyl chloride (a mixture of the primary, secondary, and tertiary isomers) is scrubbed with caustic to remove traces of hydrogen chloride, and is then fed to a digestor in which it is hydrolyzed to form amyl alcohol. Caustic soda is used as the hydrolyzing agent, and oleic acid as a catalyst. The mixture goes to a second digestor from which crude amyl alcohols are removed as a top product. Brine is formed as a byproduct of the hydrolysis reaction, and is removed from the bottom of the second digestor.

The crude alcohol is condensed, and the water fraction removed by decantation. It then goes through a series of three columns in which amylenes (a byproduct of the hydrolysis reaction), amyl chloride, and water are removed. The amylenes are used in the production of amylphenols in another process, and the amyl chloride is recycled to the digestors. Finally, the mixture of amyl alcohols is charged to a batch still where the various grades and isomers are separated by fractionation through a bubble cap column.

Reference: PETROLEUM REFINER, Sept.'53,p207. *Industrial & Engineering Chemistry,* Vol.42,2388 (1950).



Aniline— AMERICAN CYANAMID COMPANY

Application: A vapor-phase fluid-bed catalytic process for reduction of nitrobenzene to aniline.

Charge: Nitrobenzene containing less than 10 ppm nitrothiophene and hydrogen.

Product: Aniline—Freezing point —6.2° C minimum.

Description: Mononitrobenzene prepared from benzene by standard nitration processes, is fed to a lower tray of a bubble-tray tower. Heat supplied by a reboiler vaporizes the nitrobenzene into a stream of hydrogen which is fed up the tower. The mixture of nitrobenzene and hydrogen containing approximately three times the theoretical amount of hydrogen required for the reduction is passed through a porous distributor plate into a reduction chamber containing a fluidized bed of copper catalyst. Excess heat of reaction is removed by circulation of a heat-transfer liquid through tube bundles suspended in the catalyst bed. The upper portion of the reactor, essentially empty, acts as a disengaging zone and permits a major portion of the catalyst particles entrained in the gas stream to fall back into the catalyst bed. The exit gases are filtered free of catalyst on porous stainless steel filters.

The filtered gases are cooled in a condenser to separate aniline and water from the excess hydrogen which is recycled except for a small purge. The aniline is separated from water in a decanter. The crude aniline containing less than 0.5 percent unreacted nitrobenzene and about 5 percent water is distilled to remove high boilers. The water and aniline which pass overhead are condensed and redistilled in a finishing tower.

The catalyst is prepared by the adsorption of cuprammonium nitrate on silica hydrogel followed by spray drying to yield a fluidizable powder with a particle diameter of 20 to 150 microns. The catalyst is activated in place in the converter by reduction with hydrogen at a temperature of about 250° C. Careful control of the quality of nitrobenzene will give long active life catalyst (1,500 units of aniline per unit of catalyst) before regeneration is required. Regeneration may be accomplished in place by stopping the nitrobenzene feed, flushing the system with inert gas and passing air through the catalyst at 250° C — 350° C to burn off organic deposits.

The reaction is as follows:

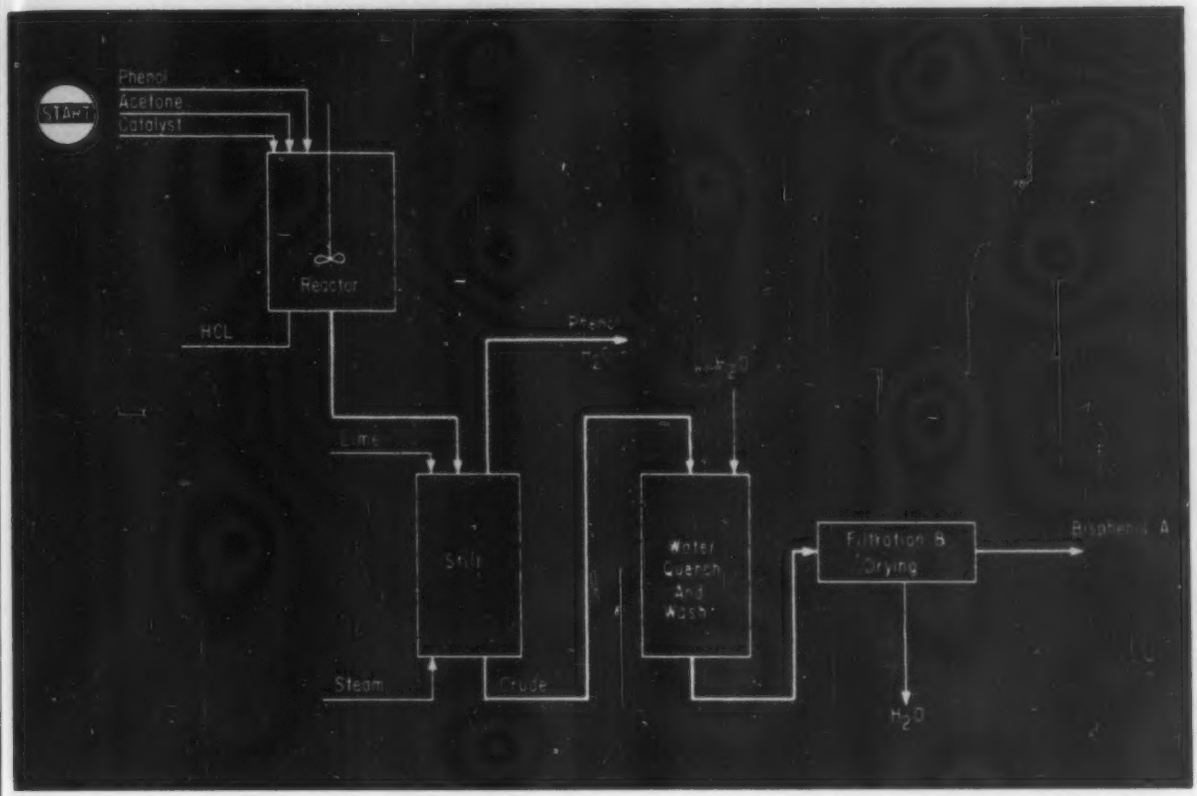
$$C_6H_5NO_2 + 3H_2 = C_6H_5NH_2 + 2H_2O$$

Operating Conditions: The reduction is carried out at 270° C and 20 psig.

Yield: The yield of aniline from nitrobenzene is approximately 98 percent of theory.

Commercial Installation: American Cyanamid Company, Willow Island, W. Va.

References: O. C. Karkalits, Jr., C. M. Vanderwaart and F. H. Megson (to American Cyanamid Company) U.S. 2,891,094.



Bisphenol A

Application: This is a process for the production of Bisphenol A (2,2 bis [4-hydroxyphenyl] propane).

Charge: Phenol, acetone, hydrochloric acid.

Product: Bisphenol A satisfactory for production of epoxy resins.

Description: Phenol and acetone in a molar ratio of 3:1 or 4:1 are charged to an acid-resistant stirred reactor. Glass-lined equipment is used ordinarily. A sulfur-containing catalyst is added, then dry hydrogen chloride gas is bubbled into the reaction mass. The temperature is maintained at 30°-40° C for 8-12 hours. The product crystallizes from the reaction mixture to form a slurry.

At the end of the reaction, the mixture is washed with water and just enough lime is added to neutralize the free acid. Vacuum and heat are applied to the reaction kettle and water and phenol distilled separately from the mixture. The batch is finished by blowing the molten product with steam under vacuum at 150° C to remove the ordor of the sulfur-containing catalyst.

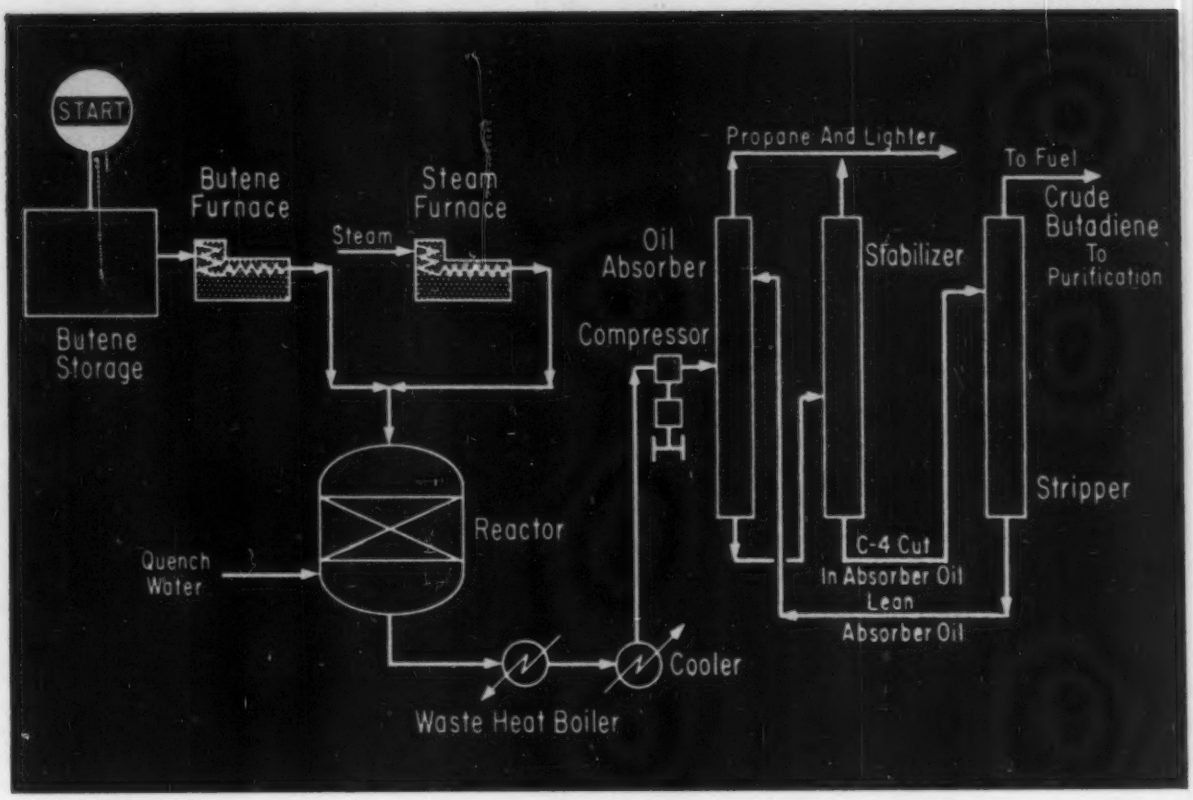
The molten product is quenched in a large volume of water, filtered, and dried. It is a light tan powder, which may be further purified by recrystallization from solvents.

Operating Conditions: The main reaction is run near room temperature, 30°-40° C, depending on the catalyst used. Water is removed from the product at about 60° C. and the final distillation of unreacted phenol and the steam deodorization are carried out near 150° C. The catalysts used may be any ionizable organic sulfur compound, including mercaptocarboxylic acids, meracptans, and hydrogen sulfide.

Yields: Yields of 98 percent based on acetone are reported.

Commercial Installations: This process or similar ones are used by Dow Chemical Company, Midland, Mich.; Monsanto Chemical Co., St. Louis, Mo.; and Shell Chemical Co., Houston.

References: R. P. Perkins (to Dow) U.S. 2,191,831 (Feb. 27, 1940); R. P. Perkins and Fred Bryner (to Dow U.S. 2,359,242 (Sept. 26, 1944); W. L. Stoesser and E. Sommerfield (to Dow) U.S. 2,623,908 (Dec. 30, 1952); Geo. T. Wilkinson (to Shell Development Co.) U.S. 2,775,620 (Dec. 25, 1956).



Butadiene From Butenes— ESSO RESEARCH AND ENGINEERING COMPANY

Application: A process for the catalytic dehydrogenation of normal butenes to butadiene-1,3.

Charge: A C_4 hydrocarbon stream containing about 80 weight percent n-butenes.

Product: A crude butadiene stream from which high-purity butadiene can be extracted.

Description: The feed is preheated to about 1000° F in the hydrocarbon superheater. The hot gases are then mixed with superheated steam and the mixture is passed through the fixed-bed catalyst.

The low partial pressures necessary for the dehydrogenation of the butenes to butadiene by the catalyst are obtained by the use of this steam. Carbon deposited on the catalyst is removed by a "water gas reaction" with steam, partially during the dehydrogenation and partially during the regeneration cycle.

The hot gases leaving the reactor go through steam generators where they are cooled and where some of the steam for the process is generated. The hot reactor effluent is further cooled in an oil quench tower and a water quench tower. Water condensed from the effluent after compression is stripped of any volatile hydrocarbon in a water stripping tower and is then discharged to a blowdown system.

After compression and cooling, the effluent enters a condensate separator. The gases from the separator are fed to the absorber where the C_4 hydrocarbons are absorbed in a light naphtha which is then recycled to the oil quench tower. The condensate from the separator, containing the unstabilized C_4 cut, is fed to the stabilizer where the lighter components are removed overhead.

The bottoms stream from the stabilizer is fed to the rerun tower where the C_5 and heavier components are removed as bottoms. The overhead stream is the crude butadiene product.

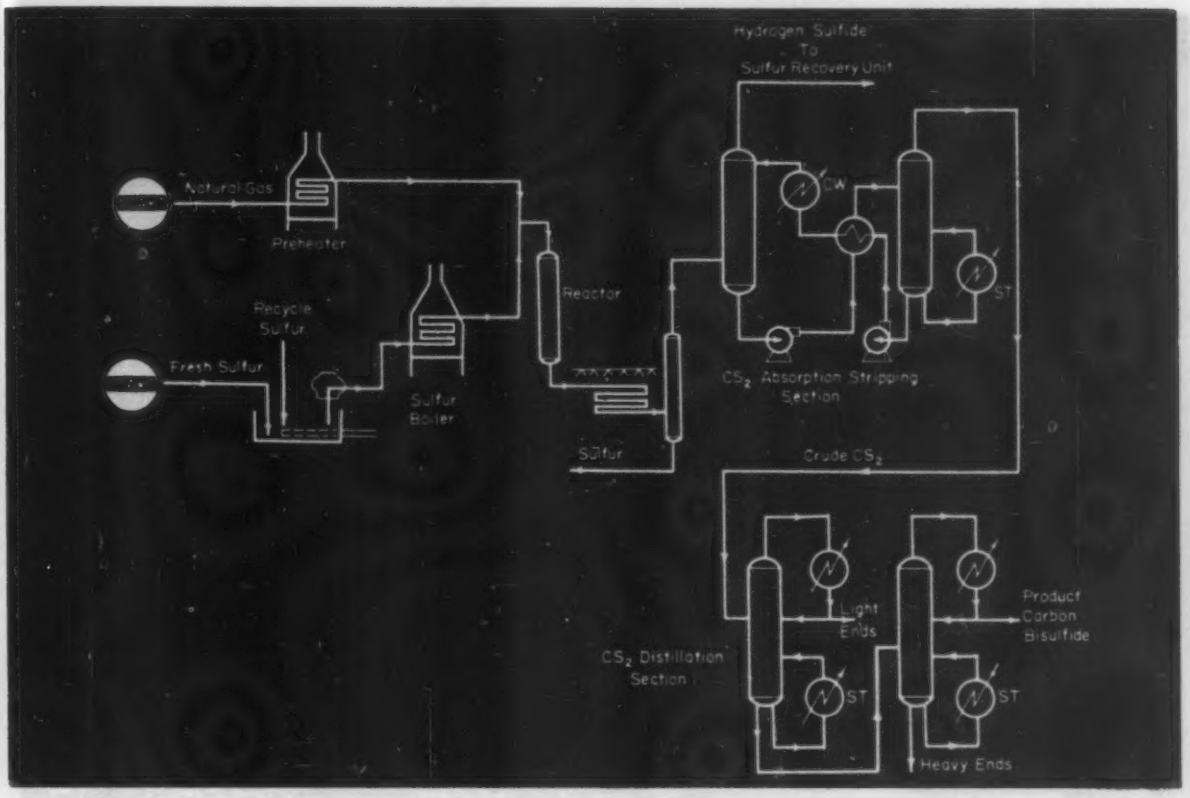
Operating Conditions: The principal operating conditions are:

Space velocity, V/H/V (Volume of n-butene as gas at standard conditions per hour per volume of catalyst)	125-225
Pressure Above Bed, psig	7-11
Pressure Below Bed, psig	2-4
Partial pressure, mm Hg. (at reactor inlet)	60-80
Steam/Butene, Gas Volume Ratio	14-18
Temperature, ° F.	1150-1250

Yields: Typical once-through yields* are as follows:

	Feed Weight Percent	Products Weight Percent
Normal Butenes	80.0	60.0
Butadiene	2.0	16.4
Other C_4's	18.0	16.0
Polymer	....	1.0
Fuel Gas and Coke	....	6.6

* Yields and operating conditions will depend upon the catalyst used.



Carbon Bisulfide

Application: A process for the manufacture of carbon bisulfide.

Charge: Natural gas, predominantly methane and containing a minimum of propanes-plus; sulfur, 99 + percent purity.

Product: Rayon-grade sulfur is melted, if necessary, and combined with recycle sulfur in an underground tank. The sulfur is maintained in the molten state at 250-270° F by steam coils, and is transferred continuously to the boiler by means of a well-type pump. The boiler produces a superheated vapor at 1100-1200° F and 20-30 psig, under which conditions most of the sulfur is in the diatomic form. The boiler is of stainless steel construction and presents maintenance difficulties due to the corrosiveness of sulfur and to the fouling tendencies of impurities in the sulfur.

Methane (natural gas) is preheated separately to 1,000-1,200° F, depending on the heavy impurities and their tendency to decompose. The preheated sulfur and methane streams are then mixed and passed down through the reactor where carbon bisulfide is formed according to the reaction:

$$CH_4 + 2\,S_2 = CS_2 + 2\,H_2S$$

The reactor is a vertical, stainless steel vessel filled with silica gel catalyst (a number of other materials may be used as catalyst) and operated adiabatically. Typical reaction conditions are: temperature, 1,050-1,150° F; pressure, 20-30 psig; vapor hourly space velocity, 400-600. Because of the endothermic reaction and corrosion problems at high preheat temperatures, intermediate reheating of the reaction mixture is necessary. Approximately stoichiometric proportions of sulfur and methane are used, and they are converted in excess of 95 percent during passage through the reactor.

The reaction yields approach theory very closely. Byproducts include light mercaptans and heavy di- and poly-sulfides. The reactor effluent is cooled in a sprayed U-bend exchanger and passed to a tank from which condensed sulfur is withdrawn at 250° F. This sulfur could be recycled, but is small in quantity and in addition contains accumulated tars.

Sulfur is de-entrained from the exit gases, and they are then fed to an absorption column in which carbon bisulfide is removed by a selective, mineral oil-type solvent. The rich oil is pumped to a stripper where the carbon bisulfide is removed and sent to the distillation section. The off gas from the absorber contains 90-95 percent hydrogen sulfide and passes to a sulfur recovery unit. Details of this unit are given elsewhere in this handbook.

The stripped carbon bisulfide is purified in two successsive distillations, with the final product being taken overhead from the second column. The distillation columns are of steel construction and utilize refrigerated overhead condensers.

The carbon bisulfide product is stored and shipped in steel containers. A blanket of water is used to minimize fire hazards. Further purification of the product is required before it can meet USP requirements.

Operating Conditions: Typical conditions for the catalytic reaction between methane and sulfur are given in the above text.

Yields: Typical over-all process yields:

Carbon bisulfide from methane	90-95 percent
Carbon bisulfide from sulfur	85-90 percent

Commercial Installations: This process or a variation is used by Columbia-Southern Chemical Corp., South Charleston, W. Va.; Food Machinery and Chemical Corp. (Westvaco Division), South Charleston, W. V.; Stauffer Chemical Co., LeMoyne, Alabama.

Reference: For a discussion of the reaction conditions, see the paper by H. Folkins, E. Miller, and H. Hennig, *Ind. Eng. Chem.*, 42, 2202 (1950).

CHLORINATED METHANES
Product Methyl Chloride
Product Methylene Chloride
Methylene Chloride Column
Methyl Chloride Column
Compressor
Drying Column
98% H_2SO_4
Caustic
HCL Scrubber
Neutralizer
32% HCL
Blower
Recycle Methane
Hot Water
Brine
Main Stripper
Main Absorber
Primary Reactor
Purified Methane
Chlorine
START
START
Product Chloroform
Product Carbon Tetrachloride
Carbon Tetrachloride Column
Heavy Ends
Chloroform Column
Intermediate Column
Storage
HCL
Secondary Reactor "B"
Secondary Reactor "A"
Recycle Methylene Chloride
Chlorine

Chlorinated Methanes

Application: This is a process for the manufacture of chlorinated methanes.

Charge: Methane and chlorine, both of 99 percent purity, are the charge materials.

Products: Methyl chloride (CH_3Cl), 99 percent purity, methylene chloride (CH_2Cl_2), 88-92 percent purity; chloroform ($CHCl_3$), 99 percent purity; and carbon tetrachloride ($CHCl_4$), 99 + percent purity, are the products.

Description: Chlorination of methane may be effected either thermally or photochemically. In the representative process described here, thermal activation is used for the primary chlorination and photochemical activation for the following secondary chlorinations. Such a process is designed for maximum flexibility regarding production rates of the four chlorinated methanes.

The primary chlorination step involves the reaction between methane and chlorine in a multitubular reactor. The reactants are preheated (by direct or indirect heat exchange with reaction products), mixed at high velocity, and allowed to react at temperatures in the range of 650°-750° F. The methane to chlorine ratio must be controlled carefully, since slight variations can alter the product distribution considerably. In addition, care must be exercised to prevent ignition and consequent degradation of products to carbon and hydrogen chloride. Thus, high tube velocities and effective heat removal are design features of the reactor.

In a typical case, chlorine and methane (including recycle) are fed to the primary reactor in a molar ratio of 0.6 to 1.0. Operating pressure is slightly above atmospheric. Chlorine conversion is essentially complete, and methane conversion is on the order of 65 percent. The effluent gases include unreacted methane, traces of chlorine, hydrogen chloride, heavy chlorinated compounds, and chlorinated methanes in the following approximate molar ratio:

Methyl chloride	6.0
Methylene chloride	3.0
Chloroform	1.0
Carbon tetrachloride	0.25

The products are cooled and sent to the main absorber where chlorinated materials are separated from methane and hydrogen chloride. The latter materials comprise 75-80 percent of the reactor effluent. The solvent for the absorber is a chilled mixture of chloroform and carbon tetrachloride. The lean gas from the absorber, containing less than 3 percent chlorinated hydrocarbons, passes to a water-cooled graphite tower where it is scrubbed with dilute (less than 15 percent) hydrochloric acid. The bottom product from this tower is 32 wt-percent acid. The off gas is then further scrubbed with caustic soda solution and finally dried with concentrated sulfuric acid. The resulting dry methane is recycled to the primary reactor by means of a blower.

The bottoms product from the main absorber is preheated and fed to the main stripper wherein residual chlorine and hydrogen chloride, plus significant amounts of the lighter chlorinated methanes are removed overhead. The off gas passes to a rubber-and brick-lined tower wherein hydrogen chloride is removed by scrubbing with 130° F. water. The tower is operated at elevated temperatures to avoid condensation of the chlorinated methanes. The overhead gas, containing 0.3-0.5 percent hydrogen chloride, is neutralized and dried by successive scrubbing with dilute caustic solution and concentrated surfuric acid.

The dry gas is compressed to about 110 psig and fed to the methyl chloride column. The overhead product from the distillation in this column contains product methyl chloride of 99 percent purity, which meets technical grade specifications. The bottoms product is fed to the methylene chloride column where 88-92 percent methylene chloride is removed overhead. Only a portion of the methylene chloride is thus removed, the remainder being left in the bottoms product for further chlorination. Thus, the bottoms from the methylene chloride column are combined with the bottoms from the main stripper and are charged to secondary reactor "A".

The secondary chlorinations are carried out in the liquid phase, using photochemical activation. Special reactors expose a maximum of liquid at close range to mercury-arc lamps. Fresh chlorine is introduced to convert methylene chloride to chloroform. The reactor operates at essentially ambient temperature, with the exothermic heat of reaction being removed by cooling coils and a reflux condenser. Hydrogen chloride escapes and is collected in scrubbing equipment similar to that described earlier in the process.

The overflow from the reactor is fed to the intermediate column, where unreacted methylene chloride is removed overhead and recycled to the reactor. The bottoms product from the intermediate column passes to a fractionator wherein USP chloroform (90.0-99.5 percent purity) is removed overhead. The bottoms stream from this second tower contains chloroform and lesser amounts of carbon tetrachloride and high boilers. This mixture is combined with fresh chlorine to form the charge for secondary reactor "B".

In this second photochemical reactor chloroform is converted to carbon tetrachloride. Design and operation of the reactor are similar to the "A" reactor. The effluent passes to a fractionator wherein 99.5 percent carbon tetrachloride is removed overhead. The bottoms product from this fractionator contains residual higher chlorinated materials formed during the three reaction steps.

A portion of the above-described process can be used if a high degree of production flexibility is not required. For example, a single thermal reactor employing moderate recycle of methyl chloride may be used. The product from the reactor is scrubbed, neutralized, and compressed. Separation of the four chlorinated methanes is then carried out by conventional straight fractionation. The ratio of methane (and recycle methyl chloride) to chlorine in the reactor feed may be as high as five to one. Production quantities of chloroform and carbon tetrachloride are limited.

Operating Conditions: Chlorination conditions vary with the product distribution desired, which in turn varies with market conditions. A representative set of operating conditions for the primary chlorination is included in the above text.

Yields: Over-all process yield, methane to chlorinated methanes, is 85-90 percent.

Commercial Installations: This process or a variation is used at the following plants: Allied Chemical Corp., Solvay Process Division, Moundsville, W. Va.; Dow Chemical Co., Pittsburg, Calif., and Freeport, Texas; Frontier Chemical Co., Wichita, Kans.; Stauffer Chemical Co., Louisville, Ky.

References: PETROLEUM REFINER, 33 No. 12,p136 (Dec. 1954); Hirschkind, W., *Ind Eng. Chem.*, 41, p2749 (1949).

Chlorine
START
Natural Gas
START
Small Recycle
Chlorination Furnace
Cooling
Ejector
Big Recycle
Uncondensed Gas
Condensation
Rectification
CH_3Cl
CH_2Cl_2
$CHCl_3$
CCl_4
HCL 32%
H_2SO_4 Spent
98% H_2SO_4
Drying
Crude Product Tank
Cooler
Deconter
H_2O
NaOH
Neutralization
Compressor
H_2O
HCl Absorption
Spent NaOH
HCl Solution

Chloromethanes— MONTECATINI

Application: A process for the manufacture of the four chlorosubstituted derivatives of methane by direct thermal chlorination of natural gas.

Charge: Natural gas and dry gaseous chlorine.

Products: Methyl chloride, methylene chloride, chloroform, carbon tetrachloride.

Description: The Montecatini process for thermal chlorination of methane allows different cycles according to the desired partition of products among the various chloromethanes and according to the form in which byproduct hydrogen chloride is to be recovered (either as a 30-32 percent commercial aqueous solution or in dry, gaseous form).

In any case, the basic process includes several common steps; some of them include different alternatives which will be mentioned below.

Chlorination. Chlorination of methane is an exothermic chain-reaction, yielding 24,000 kcal/kmol of reacted chlorine. The industrial reaction is carried out in an adiabatically operated furnace in which the evolved reaction heat is recovered for pre-heating fresh gas feed. Temperature is kept between 370° and 410° C according to the selected cycle (see below); in this way total conversion of chlorine to chlorinated products is achieved. Fresh gas feed is preheated at about 280° C before entering the furnace. The methane/chlorine ratio in the gas feed is the factor which pre-establishes the reaction conditions. Thus in order to obtain, as main products, a mixture of light chlorinated compounds (i.e. CH_3Cl, CH_2 and $CHCl_3$) a CH_4/Cl_2 ratio of at least 3,5-4 must be used when mixing fresh gas feed components. When, on the contrary, carbon tetrachloride is the desired main product, the reactants ratio must be kept between 0.5 and 0.8. However, chlorine gas must be diluted in the feed gas stream in order to avoid explosion hazards. In the Montecatini process, the double problem of pre-heating the reactants and suitably diluting chlorine in the gas feed mixture has been solved by means of two recycle steps; the first of them is represented by recycling a major portion (75-80 percent) of the hot gases leaving the furnace (the so-called "small recycle") and blending the same with cold gases, containing make up fresh feed plus uncondensed gases available after the condensation step (the so-called "big recycle").

Different Cycles: By using a single chlorination cycle it is not always possible to obtain a balanced amount of the four chlorinated products according to market requirements. Thus it is sometimes necessary to use two different cycles, one of which mainly yields light products while the second gives mainly carbon tetrachloride. In the first case methane in excess is sufficient for dilution purposes and temperature control is easily obtained. (The so-called "methane cycle"). In the second case, an inert gas must be used and to this aim nitrogen has been selected as the most suitable. (The so-called "nitrogen cycle"). Since the composition of reacted and unconverted gases is quite different in the two cases, separate furnaces and subsequent intermediate equipment must be used. The final rectification step is shared in common by both cycles.

Cooling and Hydrogen Chloride Recovery. Reacted hot gases are cooled in a water-sprayed cooler and effluent is fed to an absorption tower in which HCl is recovered. The tower can be operated either adiabatically or isothermally. The absorbing liquid can be pure water and in this case an aqueous 32 percent HCl solution is obtained as a by-product. When, on the contrary, pure dry gaseous HCl is the desired by-product, an azeotropic mixture HCl/H_2O is circulated in the tower, from the bottom of the same, the solution is sent to a stripping tower. Here pure and dry HCl gas is obtained as the top effluent while the bottom azeotropic mixture is recycled back to the absorption step.

Neutralization. The reacted gases are subsequently scrubbed with a caustic soda solution in order to eliminate small amounts of HCl and CO_2; the latter would otherwise accumulate as an inert component in the circulating gaseous mass.

Compression. Compression is necessary in order to condensate the obtained products at a sufficiently high temperature. Pressure is established according to the desired products, but it cannot be lowered beyond a given minimum value since uncondensed gases, in the "big recycling" step are used as a propellant fluid in an ejector for recycling hot effluent gases. ("Small recycle").

Drying and Separation of Crude Product. Water must be avoided both in the chlorination and in the rectification stage. Therefore, a careful drying step is necessary. The same can be accomplished in two ways, namely before or after compression. In both cases, strong H_2SO_4 (98 percent by weight) is used as a drying medium in two successive towers. The spent acid has a final strength of about 75 percent. If drying is performed before compression, the operation is simpler; if on the other hand, drying is carried out after compression, acid consumption is about 10 times lower; therefore, this second alternative is preferable in most cases.

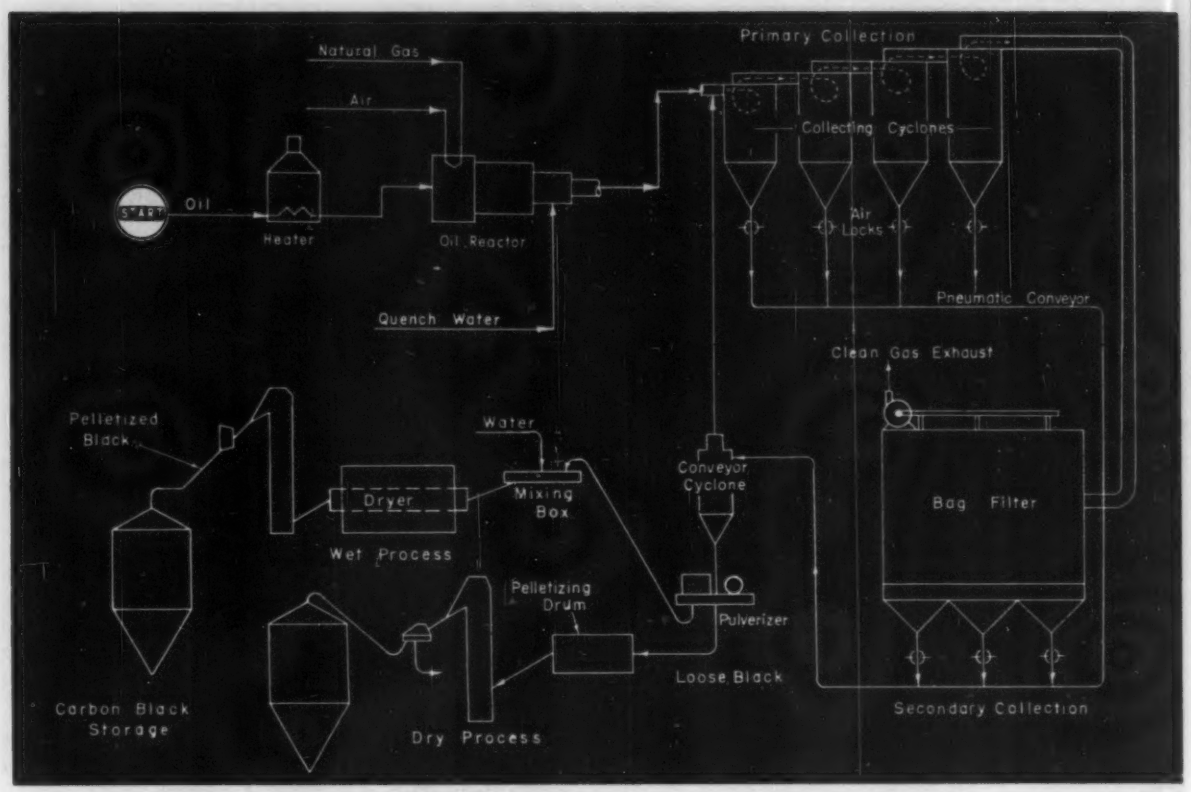
Rectification of Crude Product: This is quite a conventional step and does not present any particular difficulty. Taking into account the purity specifications usually required by market standards for chloromethanes, some care must be taken in the case of methyl-chloride (standard purity usually not lower than 99.9 percent).

Of course the assembly of rectification towers is different according to the different cycle adopted. When the plant is composed of two cycles (the "methane" cycle and the "nitrogen" cycle: see above) the rectification step is in common.

Operating Conditions: the main operative conditions have been already mentioned in the above description. Emphasis is here given again on close temperature control. Too high temperatures foster the formation of carbon black and yields in chlorine conversion are lowered.

Yields: As already stated above, by careful selection of the operating conditions and of reactants composition, almost quantitative conversion rate of chlorine can be achieved.

Commercial Installations: A plant of the kind described has been built for Allied Chemical Corp. in the United States at Moundsville (W. Va.).



Carbon Black (Oil Black)— CONTINENTAL CARBON COMPANY

Application: A process for manufacturing highly re-inforcing furnace blacks from heavy residual oils.

Charge: Heavy residual oil, natural gas, air.

Products: HAF, ISAF, and SAF carbon blacks, pelletized, bulk density 20 to 24 pounds per cubic foot.

Description: Oil is preheated in a direct-fired or molten salt type heater and atomized into a reactor in which gas and air are burned to provide the heat necessary to crack the oil. The furnace used may be one of several variations. An example is the Phillips type (Krejci, J. C. to Phillips Petroleum Company, U.S. 2,526,700, August 21, 1951) now being used under a licensing agreement. Air for the reactor is furnished by centrifugal blowers. The temperature in the oil reactor is maintained in the range of from 2,500° to 2,600° F, by controlling the oil flow rate. The oil is cracked to carbon and hydrogen with side reactions producing carbon dioxide, carbon monoxide, and water. Trace amounts of acetylene and methane are also produced.

In the quench section of the reactor, direct water sprays cool the carbon laden gases to about 1000° F. The mixture is further air cooled in a long duct to about 550° F, before entering a header leading to the collection system.

The cooled reaction mixture passes from the header into a series of four cyclones which remove 70 to 80 percent of the black then into the final cleaning step in which silicone coated glass fabric bags remove essentially 100 percent of the black. Alternatively, an electrostatic precipitator, cyclone, wet-scrubber combination may be used with the resultant slurry re-cycled to the quench for recovery.

Carbon black is continually discharged from the collection equipment by rotary valves and picked up by a pneumatic conveyor. The black is collected in a smaller diameter collecting cyclone and discharged through a high speed hammer mill to break up and disperse the very small quantities of hard agglomerates that may be present.

The pulverized carbon black is then conveyed by screw conveyor to the pelletizing system. Two methods of pelletizing are used, dry process and wet process. The dry process consists of a continuous feed of loose black into a rotating drum and a continuous discharge of pellets. In the wet process, the black is mixed with about an equal weight of water, the mixture agitated and the resultant pellets dried.

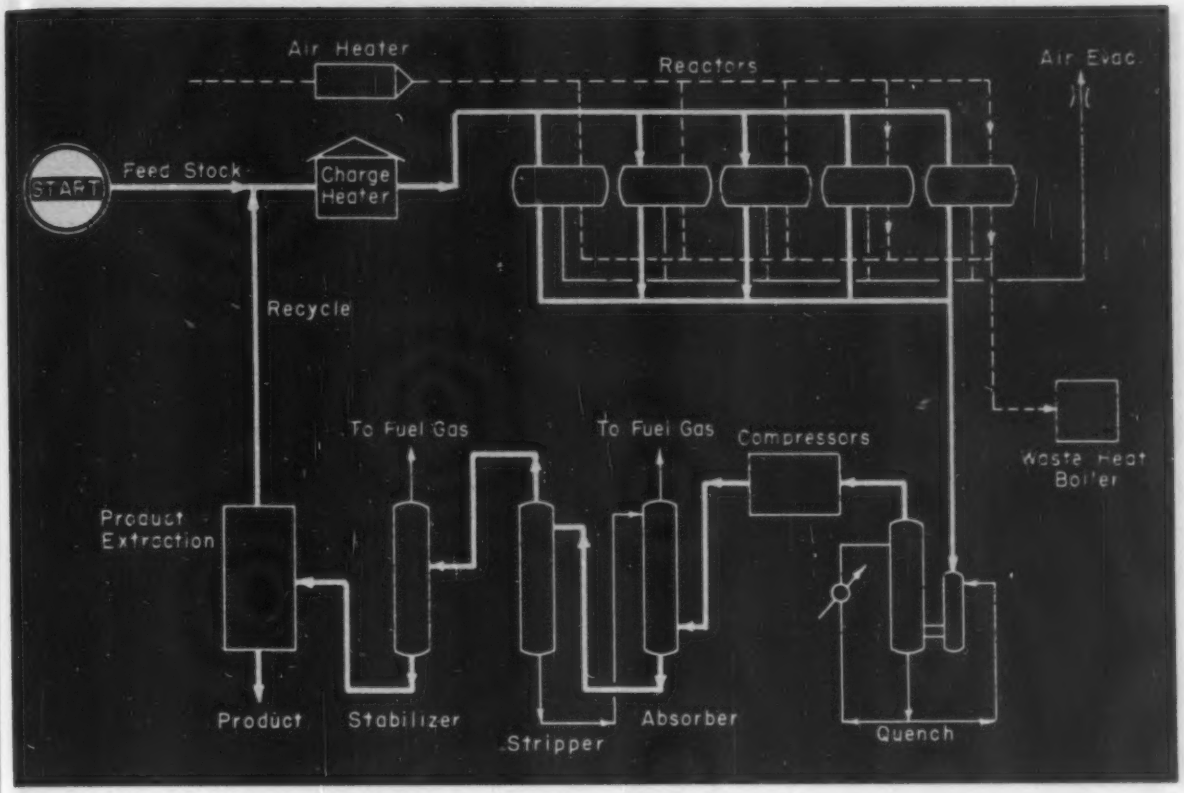
Pelletized black is shipped in bulk hopper cars or automatically packed in 50 pound three ply kraft paper valve type bags.

Operating Conditions: Reactor design and flow rates are extremely critical in determining the quality and type of black.

Yields: The process yields up to 60 percent of the carbon content of the oil feed depending on the charge stock and the grade of black desired as the finished product.

Commercial Installations: All producers use variations of the process. Examples are Continental Carbon Company at Ponca City, Oklahoma; and Westlake, Louisiana; Phillips Chemical Company, Borger, Texas.

References: PETROLEUM REFINER, Nov. '57,p227; *Industrial & Engineering Chemistry*, April '52,p685-694.



Dehydrogenation— HOUDRY PROCESS COMPANY

Application: An adiabatic fixed bed catalytic process for dehydrogenation of light hydrocarbons. Process may be operated to produce both mono- and di-olefins.

Charge: Three to five carbon paraffins, mono-olefins and mixtures thereof comprise the feed stock.

Products: Propylene from Propane; C_4 mono-olefins from normal and iso-butane; Butadiene from n-butane, n-butene or mixtures thereof; C_5 mono-olefins from normal and iso-pentane; and Isoprene from iso-pentane, iso-pentene or mixtures thereof.

Description: In a typical operation, the feed is preheated to reaction temperature prior to contact with catalyst in the fixed-bed reactors. Hot effluent from the reactors is cooled in a quench tower by direct contact with circulating oil, then passes to a compression, cooling and conventional absorption and stabilization system. The stabilized product stream is then delivered to an appropriate extraction system for recovery of the high purity product. Mono-olefins, when not removed as product, are returned with the paraffin recycle stream to the charge accumulator.

Power operated valves are controlled by a special cycle timer which programs the reaction, purging and regeneration sequences of the reactor system. Hydrocarbons are purged from the on-stream reactor prior to regeneration and combustion gases are purged after regeneration.

Catalyst: The catalyst employed is in the form of cylindrical pellets consisting of active alumina impregnated with chromic-oxide. Catalyst is regenerated in the reactors by burning off the coke deposit with preheated air. Inert granular material of high heat capacity may be mixed with the active catalyst in predetermined amounts to obtain the desired heat capacity of the catalyst bed.

Operating Conditions: In this cyclic process the operating conditions are chosen to be essentially adiabatic in nature, with the heat required for reaction during the on-stream period virtually the same as that supplied by combustion of coke deposit during catalyst regeneration. The major process conditions normally will be within the following ranges:

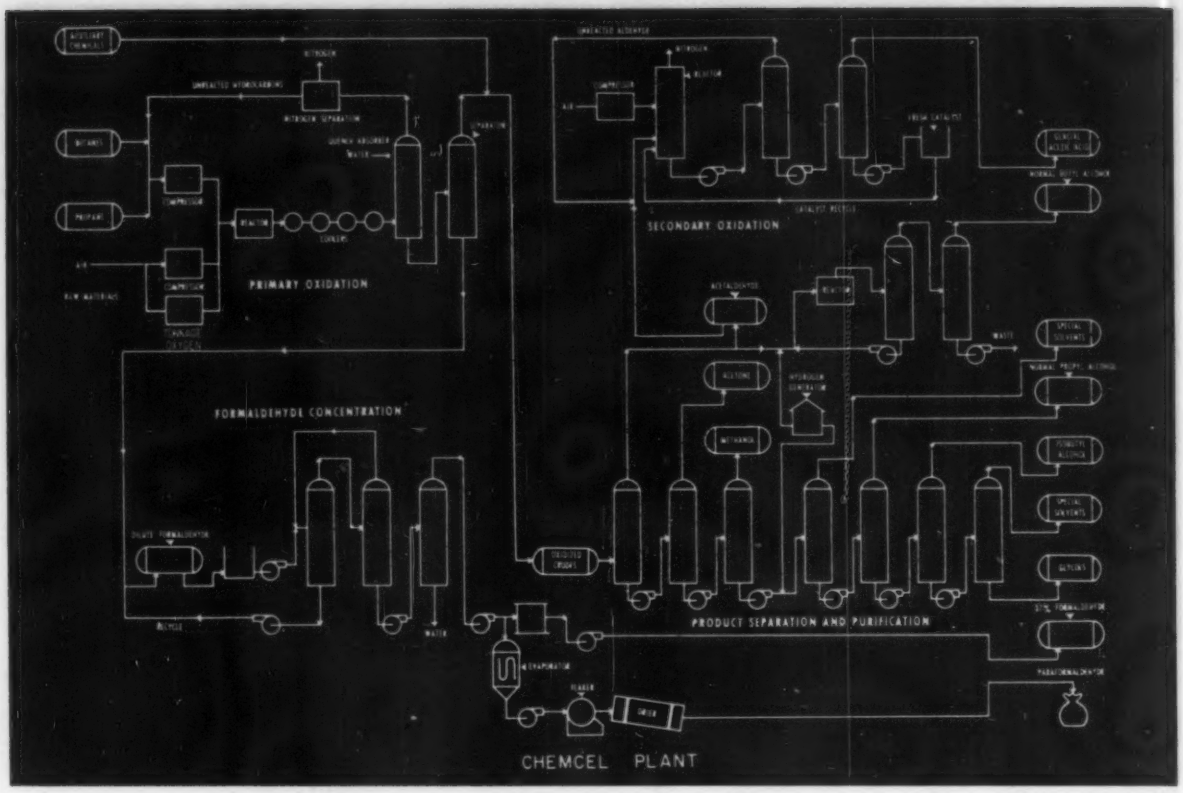
Temperature	—1000°-1200° F.
Pressure	—5" Hg absolute or higher
Space Rate	—1 to 3 Vol. of Charge/Vol. of Catalyst/Hour
On-stream Period	—5-15 minutes

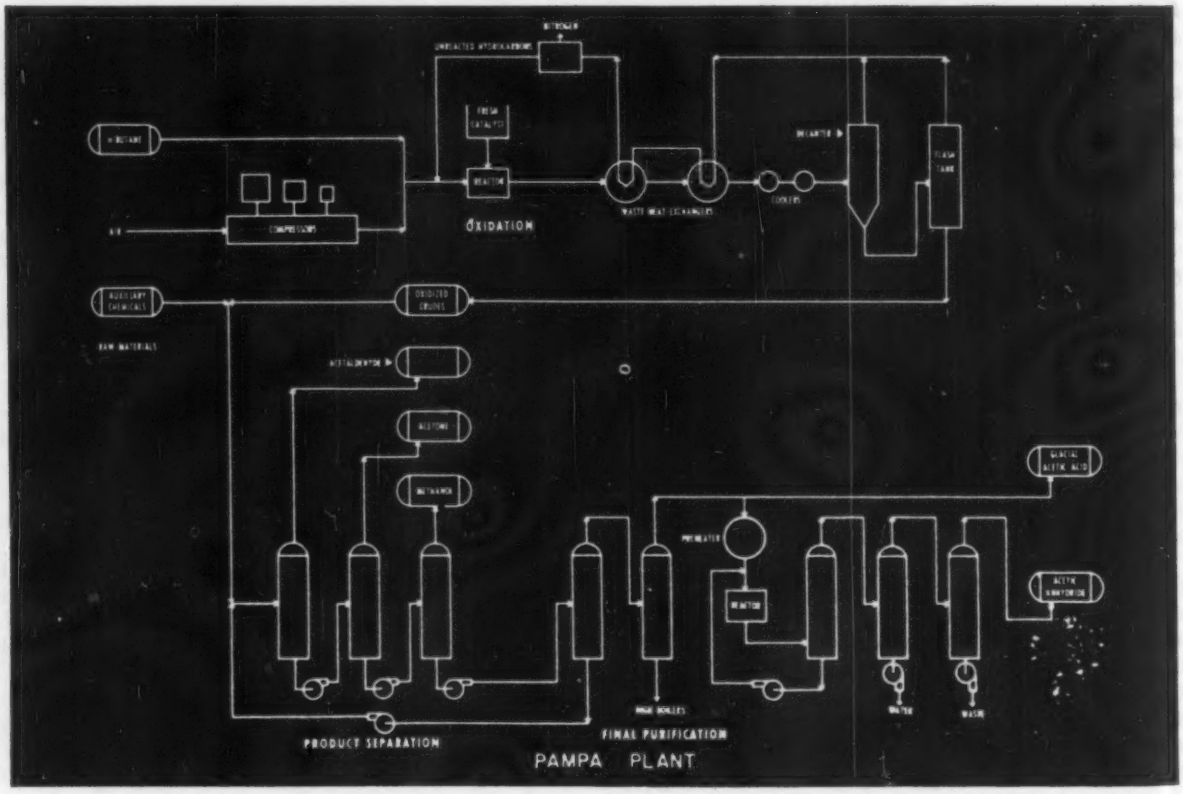
Yields: Typical ultimate yields of butadiene from *n*-butane are shown in the table below.

	Fresh Feed Weight Percent	Ultimate Yield Weight Percent
Dry Gas (Including H_2)	.....	20.0
Propylene	.....	7.6
Propane	.....	3.4
Isobutane	1.0	.....
n-Butane	99.0	.....
Butadiene	.....	60.0
C_5+	.....	1.5
Coke	.....	7.5
	100.0	100.0

Commercial Installations: Ten units are in operation or under construction with a total nominal design capacity in excess of 357,000 annual short tons of butadiene, or equivalent.

Reference: PETROLEUM REFINER, Dec.'54p.173.


PRIMARY OXIDATION
SECONDARY OXIDATION
FORMALDEHYDE CONCENTRATION
PRODUCT SEPARATION AND PURIFICATION
CHEMCEL PLANT


OXIDATION
PRODUCT SEPARATION
FINAL PURIFICATION
PAMPA PLANT

Direct Oxidation of Propane-Butane—CELANESE CORPORATION OF AMERICA

Chemcel Plant

Application: This process is for the production of a number of organic aliphatic oxygenated chemicals and some deriviatives from these chemicals.

Charge: Propane and butanes are consumed principally, although some other hydrocarbons would be permissable.

Products: The products are acetic acid, acetaldehyde, formaldehyde in various forms and mixtures with other materials, acetone, alcohols, esters, several glycols and mixtures of alcohols or ketones designated as solvents.

Description. The Chemcel operation, which is continuous, starts with the compression of air for supply both to a tonnage oxygen plant and directly to the oxidation reactor. The oxygen plant employs refrigeration to separate oxygen from nitrogen and trace quantities of other compounds in the air. The specified hydrocarbon gases are compressed separately and an excess of hydrocarbons is used to control subsequent reaction. The separate gas streams are united and fed to the oxidation furnace where partial oxidation of the hydrocarbons in the gas stream occurs. This primary oxidation is effected in a group of identical furnaces, operated in parallel, which provide for preheating the mixture as well as suitable conditions for the reaction. After brief residence in the furnaces, the gas stream, which has become enriched with primary products formed in the hot reaction chambers, is quenched and absorbed in towers containing water. Vented from these absorbers are unreacted hydrocarbons, which are recycled to the compressors for re-use, and nitrogen under pressure which can be used for driving turbines.

At this stage, a separation of the crude water-chemical mixture is effected. Dilute formaldehyde is isolated first and is subsequently concentrated to the usual water solution known as formalin. Some of the formalin is processed, essentially by dehydration, to yield paraformaldehyde and trioxane.

The portion of the water-chemical mixture remaining after formaldehyde removal is subjected to appropriate procedures for separating and purifying the various chemical components consisting largely of alcohols, aldehydes, ketones and oxides. Chemicals emerging from this step are then ready either for marketing or for additional chemical processing to produce up-graded materials.

Multi-purpose aldoling units up-grade a variety of chemicals, with n-butanol, 3-methoxy butanol, and trimethylolpropane in commercial production.

These advanced processing steps include secondary oxidation, hydrogenation and esterification. In these steps, techniques are employed involving simple and azeotropic distillations, fractionation, solvent-type extraction, evaporation, absorption and other unit processes.

Operating Conditions: These do not for the most part involve extremes, but rather entail careful control of pressures, temperatures, rate of feed, catalyst and air-hydrocarbon ratios.

Yields: The operations are inherently flexible in that process equilibria can be controlled to the extent of allowing significant changes to be made in the outputs of the various chemicals.

Commercial Installation: This plant has been in production since 1945 and is located near Bishop, Texas.

Pampa Plant

Application: This process is for the manufacture of various organic aliphatic oxygenated chemicals.

Charge: The charge is primarily normal butane, although some higher hydrocarbons and propane can be tolerated.

Products: The principal products are acetic acid and acetic anhydride. Other products are vinyl acetate, acetaldehyde, acetone, methanol, propionic and butyric acids, and methyl and ethyl acrylates.

Description: Compressed air and butane are fed to vessels where the oxidation of the hydrocarbons takes place. The reaction-product mixture is run through coolers, including a battery of air-type heat exchangers, and then to separators where nitrogen and other gases are released. As this nitrogen is under considerable pressure, it is used to drive turbines in the process. The other component of this gas is the unreacted hydrocarbon material which is recycled to the reactors.

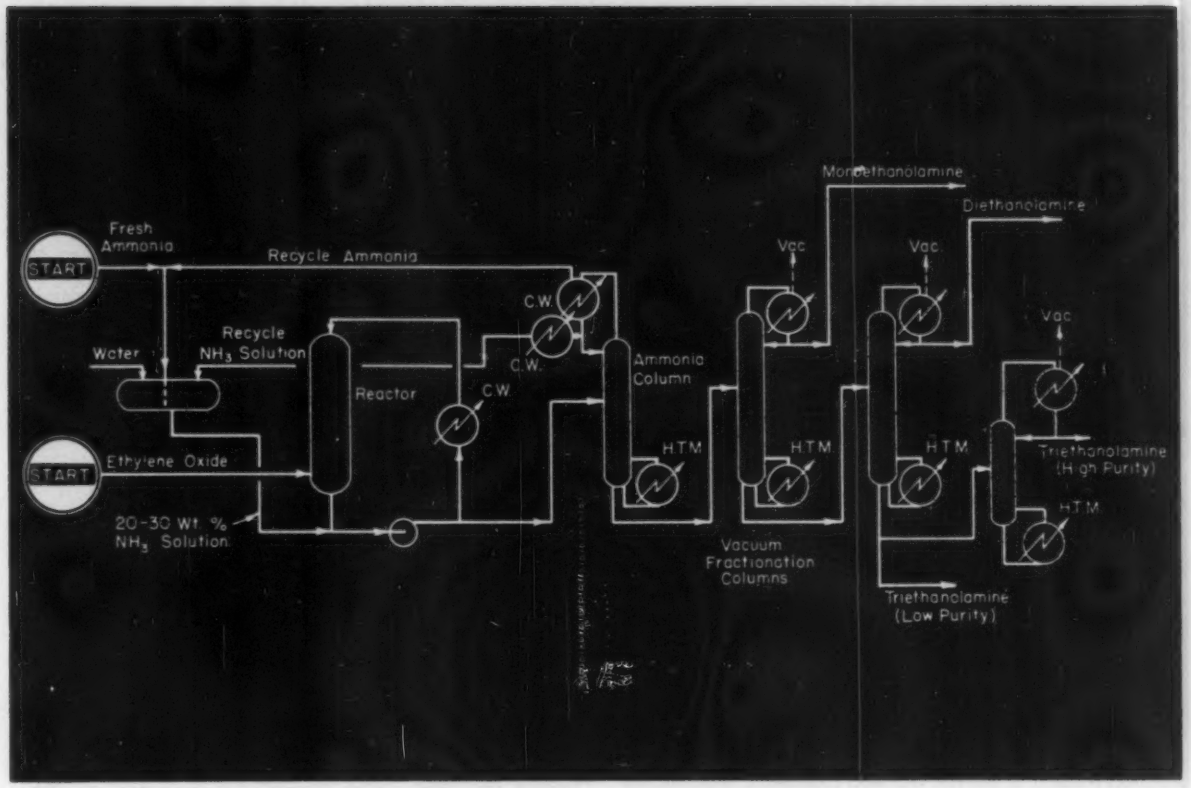
The liquid extract, or oxidized crude, is processed further to effect a separation of acetic acid, the major product, from both relatively lower and higher boiling materials. The acetic acid, after being separated from the oxidized crude mixture is fed to the anhydride unit, which has the capacity for high-efficiency conversion of all acetic acid produced (design capacity 1,800,000 pounds per week) to acetic anhydride. Also at this end of the plant is a vinyl acetate unit with design capacity of more than 30 MM pounds per year and an acrylate ester unit to produce methyl acrylate and ethyl acrylate.

In addition to the main process equipment, a "utility" or "special products" unit is provided. This unit is comprised mainly of reaction and storage tanks and three large fractionating towers together with necessary auxiliary facilities. It is designed for either batch or continuous production and can operate both on co-products from the principal process streams and on large volume speciality products.

In addition to adopting a modified version of the basic process used in the Chemical plant, a number of changes were made in equipment design. Perforated plate or sieve-type process columns are standard for the plant. Sieve trays were used because they were less expensive initially and are very satisfactory as to operating flexibility, ease of control and quality of product.

Another difference in design of the two plants is the use of air-cooled heat exchangers which are used to handle approximately 80 percent of the total cooling load at Pampa. This reduces the plant's dependence upon the vagaries of the weather in providing water for cooling purposes as the plant is situated in a region of scanty rainfall.

Commercial Installation: This plant has been operating at a location about six miles from Pampa, Texas, since late in 1952.



Ethanolamines

Application: A process for the manufacture of ethanolamines.

Charge: Ethylene Oxide, 99.5 percent purity; anhydrous ammonia.

Products: Monoethanolamine $NH_2C_2H_4OH$, 99 wt percent purity; Diethanolamine $NH(C_2H_4OH)_2$, 98 wt percent purity; Triethanolamine $(N(C_2H_4OH)_3$, 98 wt percent and 83 wt percent purities.

Description: Monoethanolamine (MEA) diethanolamine (DEA), and triethanolamine (TEA) are produced commercially by reacting ethylene oxide and ammonia. Through control of reaction conditions the distribution of the amines in the product may be varied in accordance with market requirements. Since 1956 DEA has been in greatest demand; but in 1953 MEA was the leader and in 1951 more TEA was produced than DEA and MEA combined. Thus, commercial plants for the production of ethanolamines must be somewhat flexible to accommodate market variations.

Liquid ethylene oxide is charged separately to the reactor, where it is contacted by a 20-30 wt percent aqueous ammonia solution in the presence of an excess of recycled reaction product. The reactions are quite rapid and exothermic; in the representative case shown, the reaction mixture is circulated through an external cooler at a high recycle: fresh feed ratio. The makeup ammonia solution is added to the suction of the circulating pump.

The reactor is a vertical steel vessel about half-filled with liquid. Internal packing and auxiliary cooling coils may be used. The reactor contents are maintained at 85°-120° F and about 10-20 psig (some types of reactors are operated at higher pressures). Since ethylene oxide reacts faster than MEA and DEA than with ammonia, careful control of the ethylene oxide: ammonia ratio is exercised. The effect of reactant ratio is shown in the following tabulation:

Weight Ratios of Ethanolamines in Reactor Product

	Moles ethylene oxide/mole ammonia		
	0.1	0.5	1.0
MEA	75-61	25-31	12-15
DEA	21-27	38-52	23-26
TEA	4-12	37	65-59

In practice, the ratio will range from 0.1 to 2.0 moles ethylene oxide per mole of contained ammonia, with usual operations employing ratios of 0.3-0.6. Conversion of ethylene oxide is essentially complete, with yields of the desired amines on the order of 95 percent. Some heavy ends are formed, these being principally higher ethylene oxide ethers of TEA.

The net reaction product is withdrawn from the circulating pump and fed to an atmospheric distillation column where ammonia and water are removed overhead. These products are returned to the ammonia solution tank where they are blended with fresh ammonia. When operations are such that high yields of TEA are produced, the bottoms from this column may be marketed directly as lower purity (83 wt percent) triethanolamine. Otherwise, the bottoms stream is fed to the vacuum distillation columns for further separation.

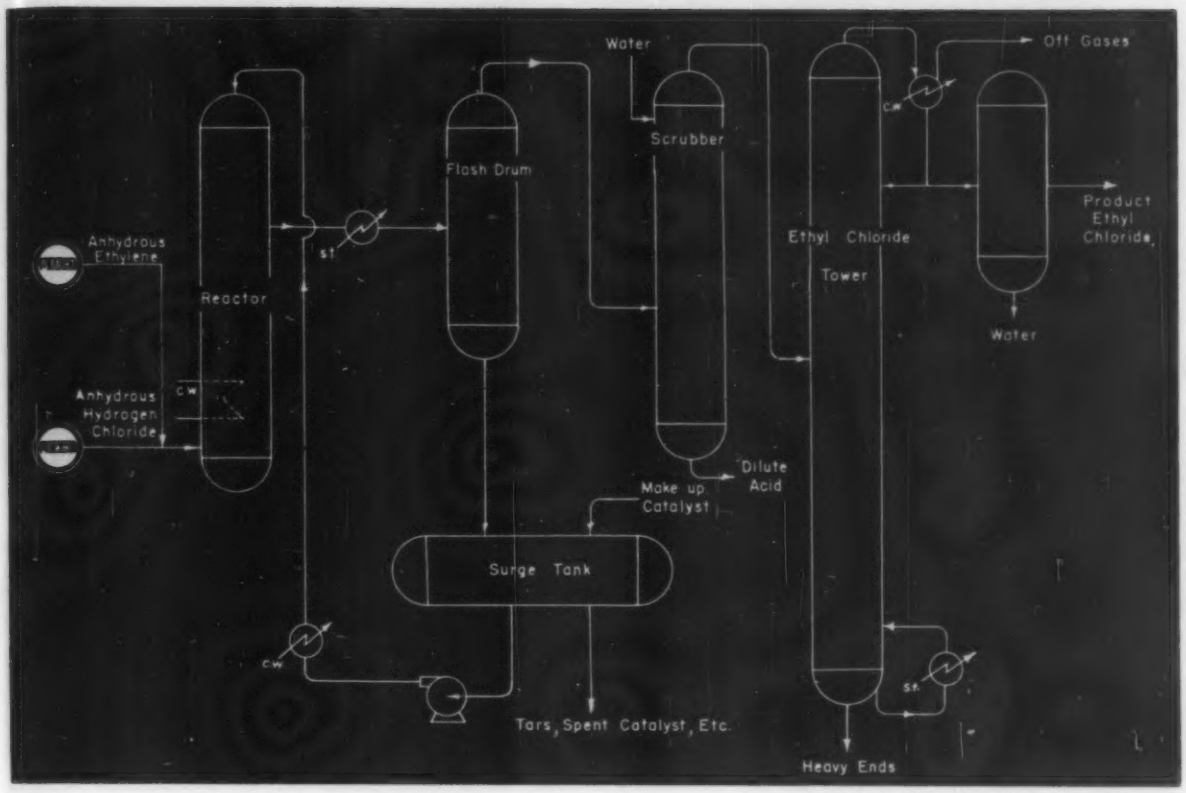
The vacuum columns are designed for a high degree of flexibility in operation. They are of stainless steel construction, contain 20-30 trays, and are reboiled by Dowtherm or equivalent heat transfer medium. The overheads from the first two columns are 99 percent MEA and 98 percent DEA products. The bottoms from the second column may be sold as lower-purity commercial TEA, but in general are fed to a final vacuum column to improve color and increase purity to 98 wt percent.

The ethanolamines are stored conventionally, and shipped from the plant in steel drums and tank cars.

Operating Conditions: Reaction conditions vary with the distribution of the three amines desired; a discussion of this point is included in the above text.

Yields: Over-all process yields of the three amines are on the order of 95 percent, based on both ethylene oxide and ammonia.

Commercial Installations: This process or a variation is used by Carbide and Carbon Chemicals Co., South Charleston, W. Va., and Seadrift, Texas; Dow Chemical Co., Midland, Mich., and Freeport, Texas; Jefferson Chemical Company, Port Neches, Texas; Allied Chemical and Dye Corp., Orange, Texas; Olin-Mathieson Chemical Corp., Brandenburg, Ky.



Ethyl Chloride

Application: This is a process for the production of pure ethyl chloride.

Charge: Hydrogen chloride (anhydrous) and ethylene (90-95 percent).

Product: Ethyl chloride, 99 percent minimum purity.

Description: Anhydrous hydrogen chloride and dry ethylene are mixed in approximately equal molecular proportions and charged to the reactor. A frequent source of ethylene for this process is the purge gas stream from a polyethylene unit. The mixed gases at 95°-100° F enter the vertical reactor and pass upward through the catalyst solution, which is a mixture of aluminum chloride in ethyl chloride or in a higher-boiling chlorinated solvent. The hydrochlorination reaction is exothermic and the heat is removed by cooling coils immersed in the reacting mass. A pressure of about 40 psi is required to maintain the reaction products in the liquid phase. The conversion of both reactants is essentially complete and the yield of ethyl chloride is about 90 percent.

The excess liquid in the reactor overflows into a heater and thence to a flash drum. The vapor, equivalent to the net production of ethyl chloride when the product is used as a reaction medium, or to the total production when another solvent is used, is passed to the purification system. The liquid is pumped to a surge tank where aluminum chloride is added as a catalyst makeup and the fresh, cooled mixture is pumped to the reactor.

The vapor from the flash drum is primarily ethyl chloride with minor amounts of methane, ethylene, hydrogen chloride, and heavier chlorinated hydrocarbons. A water scrub removes the hydrogen chloride and the organic vapors are fed to the ethyl chloride product tower. In this tower, the non-condensable gases are vented and ethyl chloride and water are the overhead product. The product is dried by decantation and sent to storage.

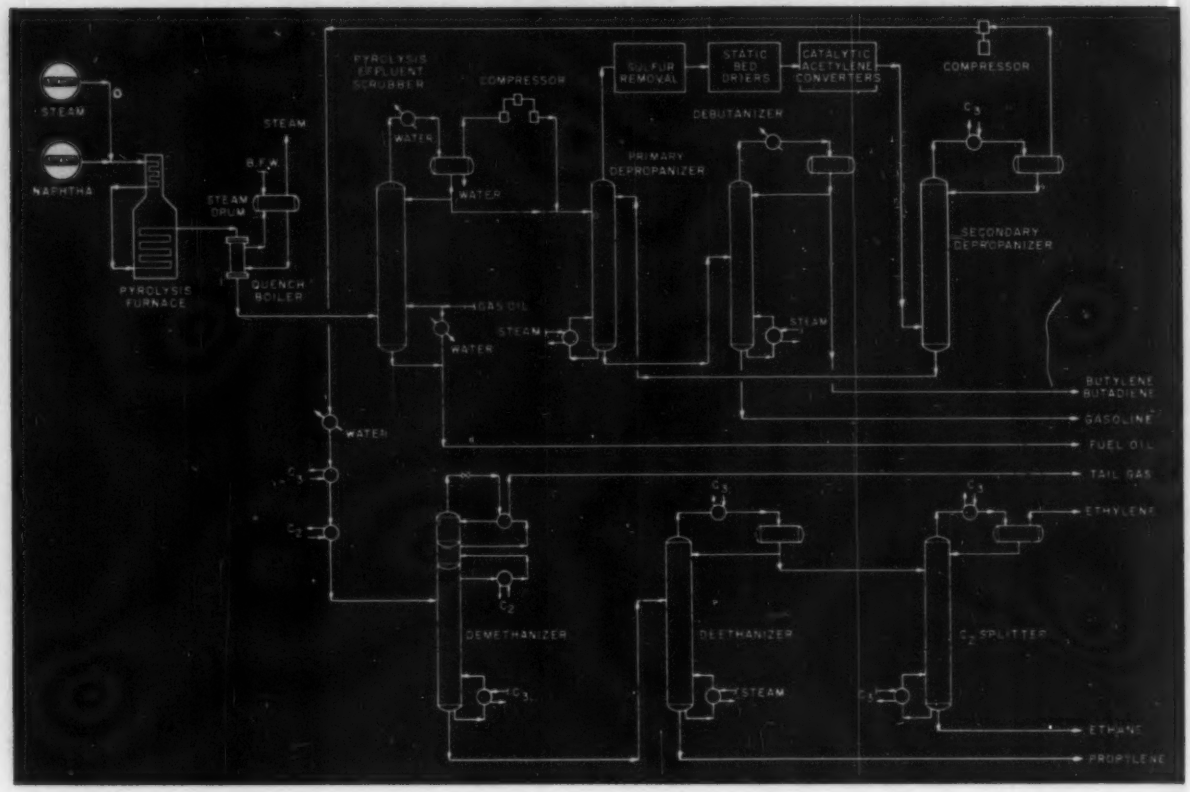
One unique feature of the process is the ease of integration with polyethylene operations. Purge gas from the polymer plant is normally of sufficiently high purity for ethyl chloride manufacture, while the HCl is easily made by direct combustion of chlorine with by-product hydrogen from the cracking plant for ethylene. For these reasons ethyl chloride is becoming a frequent co-product of polyethylene.

Operating Conditions: The reaction conditions given represent a compromise between unfavorable equilibrium conversions at higher temperatures and slow reaction with incomplete conversion at lower levels. The pressure is needed only to maintain the liquid state in the reactor.

Yields: The over-all yield of ethyl chloride is about 90 percent.

Commercial Installations: This process or variations is in use at the following plants: Ethyl Corporation, Baton Rouge, La., Deer Park, Texas; Dow Chemical Company, Midland, Mich., Freeport, Texas; and National Distillers and Chemical Corp., Tuscola, Ill.; Shell Chemical Corp., Deer Park, Texas; E. I. du Pont de Nemours and Co., Deepwater, N. J., and Antioch, Calif.

Reference: Petroleum Refiner, Dec.'54,p136.



Ethylene— THE M. W. KELLOGG COMPANY

Application: A process for the production of ethylene by the steam pyrolysis of petroleum feeds.

Charge: Refinery gas, ethane, propane, butane, pentane, natural gasoline, light and heavy naphthas, gas oil and heavier fractions.

Products: Ethylene in purities up to 99.9 mole percent also valuable olefinic and aromatic products in addition to a tail gas consisting of hydrogen and methane.

Description: The flow diagram illustrates a typical low temperature fractionation unit for producing ethylene from a naphtha charge stock. Naphtha and steam pass through the high temperature coils in the pyrolysis furnace, where cracking takes place.

The cracked products are partially cooled in steam generating facilities before final cooling in a scrubber column from which a fuel oil fraction is withdrawn.

The overhead, consisting of gasoline and lighter components, is compressed and charged to a split depropanizer system from which propane and lighter components are separated from butane and heavier. Sulfur removal, drying and acetylene conversion also take place in the split depropanizing step.

The depropanized bottoms flow to a debutanizer from which C_4s are withdrawn as an overhead product and gasoline as a bottoms product.

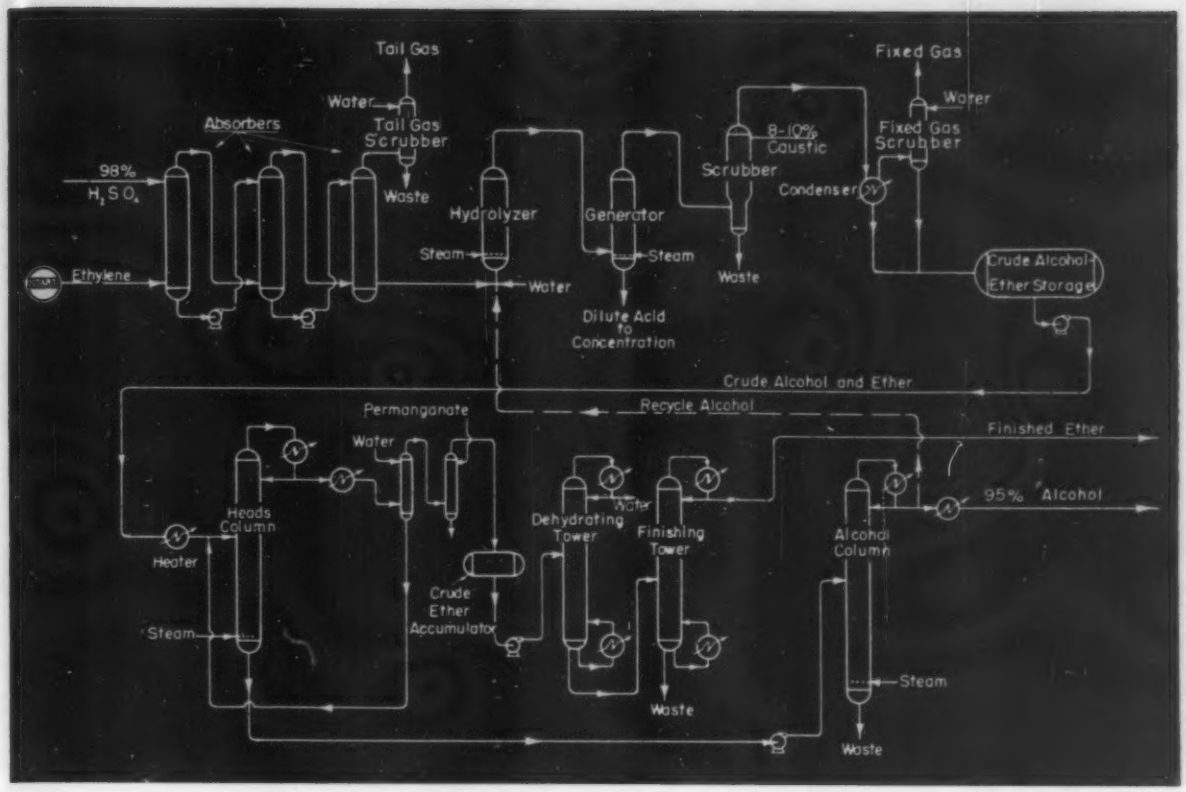
Depropanizer overhead is compressed and sent to the demethanizer where methane and hydrogen are removed as an overhead product by low temperature fractionation. The demethanizer bottoms flow to the de-ethanizer from which the C_2s are separated from the bottoms C_3 product.

The C_2 stream is separated by low temperature fractionation into an ethylene product stream and an ethane product stream which could also be vaporized and cracked to yield additional ethylene.

Refrigeration is supplied by an external propylene-ethylene cascade system and also by gas expansion.

Yields: Ethylene yields of 25 weight percent may be produced in the naphtha pyrolysis furnace effluent. The ethane produced from this pyrolysis could also be cracked to yield approximately 4 additional weight percent ethylene. The C_3 product fraction consists of 90 to 95 percent propylene thereby eliminating the need for propane-propylene splitting. The C_4 fraction is over 95 percent unsaturated and contains a high percentage of butadiene. A high octane gasoline product is also produced in this process.

Commercial Installations: Fourteen plants have been designed and built or are being built to yield a total production of approximately 5 million pounds per day of ethylene.



Ethyl Alcohol and Ethyl Ether

Application: The esterification-hydrolysis process for the manufacture of ethyl alcohol and ethyl ether.

Charge: Ethylene, 35-95 percent purity; concentrated sulfuric acid, 98 percent strength.

Products: Ethyl alcohol, 96 percent purity (192 proof); ethyl ether, 99 percent purity.

Description: A plant designed to produce both ethyl alcohol and ethyl ether by this process can be operated primarily for alcohol, the by-product ether amounting to about 5-10 percent of the total production, or primarily for ether with little or no alcohol being produced.

The initial step is the reaction of ethylene and sulfuric acid in a plate column to form a mixture of ethyl- and diethylsulfates. The size of the column varies inversely with ethylene content of the charge gas and operating pressure. For pressures as low as 100 psig and for dilute gas, more than one tower may be required. Internal cooling coils are provided to maintain operating temperatures in the range 130-170° F.

The reactor product flows to the hydrolyzer where alcohol is produced and acid regenerated. If the emphasis is on ether production, the residence time is increased and alcohol is recycled to the hydrolyzer. The resulting reactions are:

$$C_2H_5OH + C_2H_5HSO_4 \rightarrow C_2H_5OC_2H_5 + H_2SO_4$$

$$C_2H_5OH + (C_2H_5)_2SO_4 \rightarrow C_2H_5OC_2H_5 + C_2H_5HSO_4$$

For full ether production, residence times on the order of three hours and temperatures as high as 250° F. may be required. The hydrolyzer is a lead-lined steel vessel containing an inner layer of acid-proof brick.

The hydrolyzate is pressured to the generator where ether, alcohol, and water are steam-stripped. The dilute acid (50-60 percent) from the generator is sent to concentration; the stripped vapors are neutralized with 8-10 percent caustic in a packed scrubber. The vapors from the scrubber are condensed, with non-condensibles being given a final water scrub.

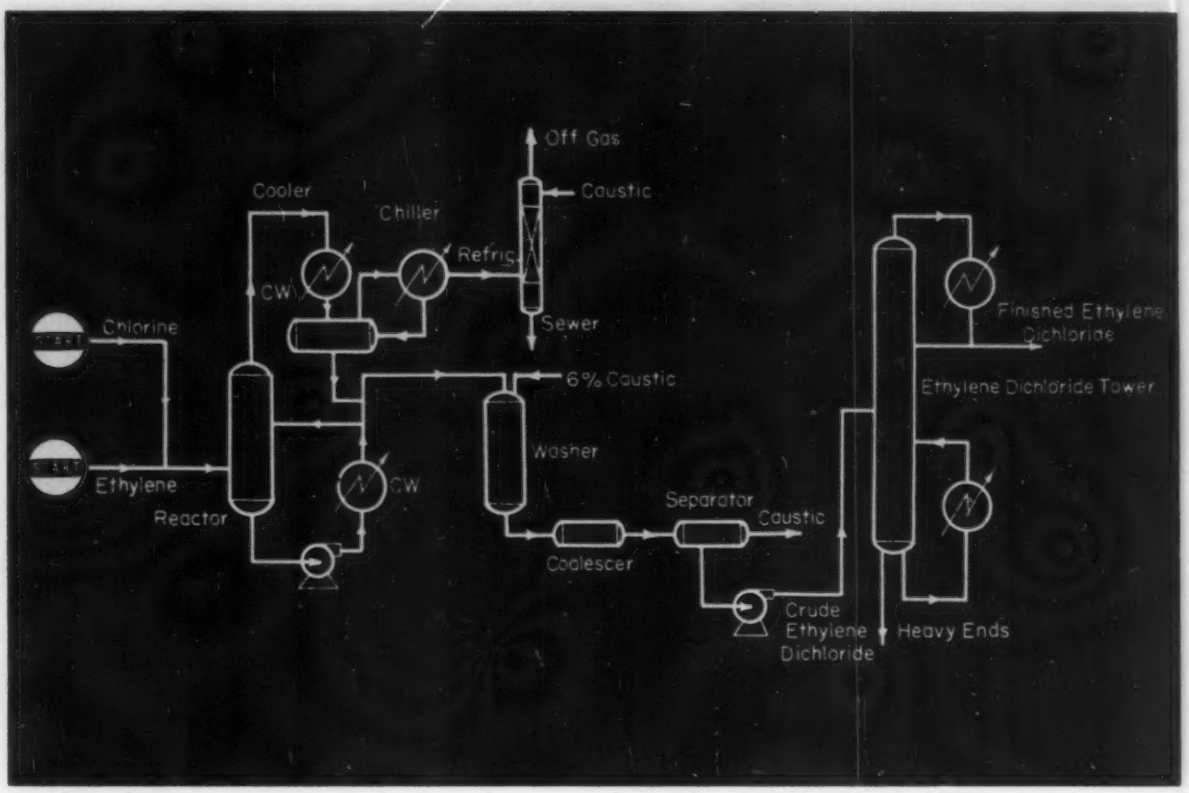
The crude alcohol-ether mixture may be separated by various schemes of fractional distillation. In the process shown, a heads column separates crude ether overhead which is finished by a permanganate treatment, dehydration, and final distillation. The bottoms product from the heads column is distilled to 192 proof alcohol.

For certain end uses, a more elaborate alcohol finishing system is necessary. A prefractionator removes heavy ends and an intermediate water-extractive distillation removes odorous impurities and oils. A final stripping of the 192 proof alchol may also be required.

Operating Conditions: Variable, according to the primary product desired. Some of the ranges are given in the above text.

Yields: Over-all process yield is about 90 percent, alcohol plus ether from ethylene.

Commercial Installations: This process or a variation is used at the following plants: Esso Standard Oil Co., Baton Rouge, La., and Linden, N. J.; National Distillers and Chemical Corp., Tuscola, Ill.; Union Carbide Chemicals Corp., South Charleston, W. Va.; Texas City, Tex., Whiting, Ind.



Ethylene Dichloride

Application: A process for the manufacture of ethylene dichloride (1,2 dichloroethane).

Charge: Chlorine, 99+ percent purity; ethylene-rich gas.

Product: Ethylene dichloride, 99+ percent purity.

Description: Ethylene dichloride is produced commercially by the chemical combination of ethylene and chlorine. The ethylene may contain diluents such as hydrogen and methane, but in general should contain no impurities heavier than propane. Frequently, the ethylene has a purity of 90 percent or better.

Ethylene and chlorine are blended in a molar ratio of 1.05-1.10 to 1.00 and charged to the reactor. The reaction takes place in the liquid phase in the presence of a considerable excess of reaction products. The exothermic heat of reaction is removed by circulating the reaction mixture through an external heat exchanger (other means for heat removal, such as internal coils and jacketed walls, may be used). When the ethylene charge is of high purity, the reaction is quite rapid, and the design of the reactor not overly critical. In general, the reactor is a vertical steel vessel half-filled with ethylene dichloride. When inert gases are present, packing or other means may be used to improve gas-liquid contact. Gases are admitted through sparger pipes at the bottom of the vessel.

The reactor contents are maintained at 100°-120° F. The operating pressure for high-purity ethylene charge is on the order of 10-20 psig, but may be higher for more dilute ethylene charge streams. The yield of ethylene dichloride from chlorine is 90-95 percent. The side products include hydrogen chloride, propylene dichloride, and polychloroethanes. It is sometimes feasible to add small amounts of materials such as ferric chloride or ethylene dibromide to increase the yield of ethylene dichloride.

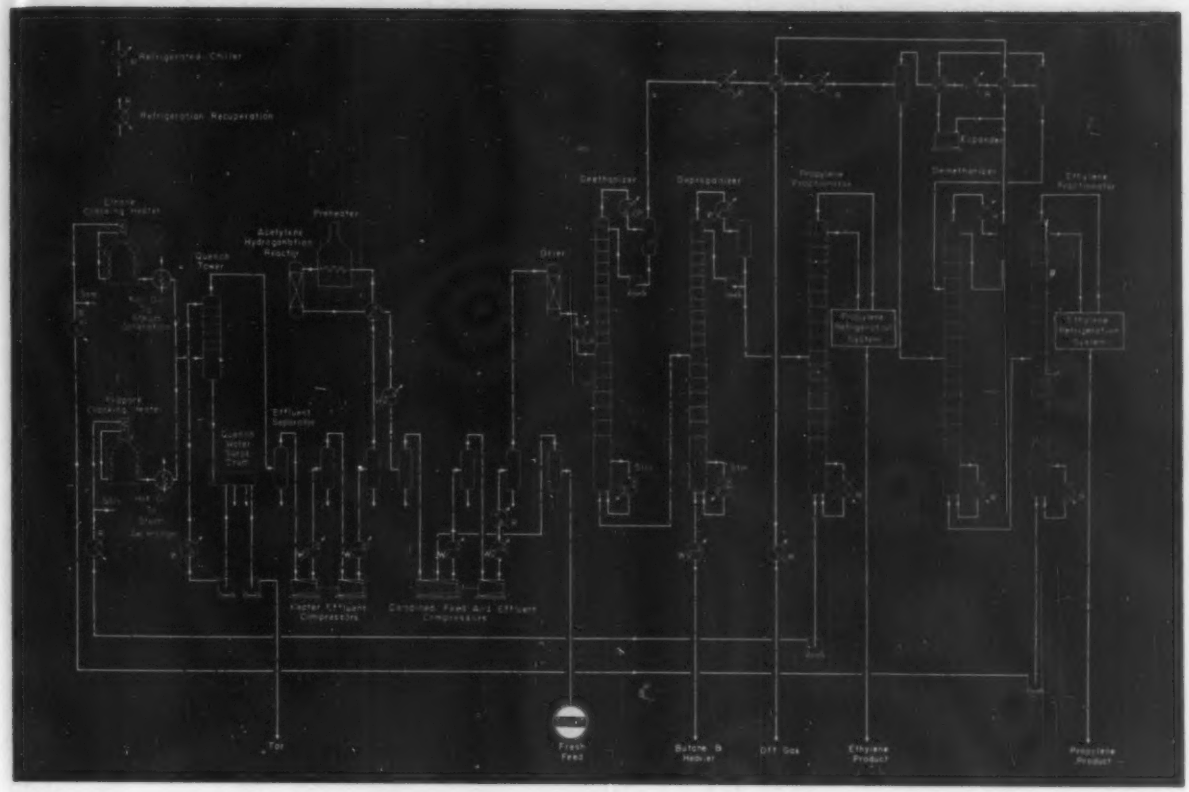
Both vapor and liquid products are removed from the reactor. The vapors pass to water-cooled and refrigerated exchangers for the recovery of ethylene dichloride, and thence to a scrubbing tower where hydrogen chloride is removed with dilute caustic. The vapors finally issuing from the vent contain hydrogen, methane, ethylene, and ethane.

The liquid products from the reactor are washed with 6-8 percent caustic in an agitated vessel. They then pass through a coalescer to a separator tank where the lower layer of crude ethylene dichloride is withdrawn.

Final purification of the ethylene dichloride is accomplished in a conventional atmospheric distillation column. The finished product has a purity of 99+ percent, and is stored in steel containers.

Yields: Over-all process yield of ethylene dichloride from chlorine is 90-95 percent.

Commercial Installations: This process or a variation is used at the following plants: Carbide and Carbon Chemicals Co., South Charleston, W. Va. and Texas City, Texas; Dow Chemical Co., Freeport, Texas and Midland, Mich.; Ethyl Corporation, Baton Rouge, La. and Houston; Monsanto Chemical Co., Texas City; Diamond Alkali Co., Deer Park, Texas.



Ethylene and Propylene— THE LUMMUS COMPANY

Application: A process for the production, recovery and purification of ethylene and propylene.

Charge Stock: Refinery gases, ethane or propane.

Products: Ethylene and/or propylene at the desired purity up to 99.9-mole percent.

Description: The flow diagram illustrates a plant to produce ethylene and propylene from ethane and propane, and to recover these olefins.

Ethane and propane entering as fresh feed plus unconverted ethane and propane are recovered to provide the feed to the cracking heaters.

Separate furnaces are used for cracking ethane and propane in order that each be cracked at the optimum conditions for maximum yield and on-stream time. The effluents from the furnaces pass through transfer line exchangers and are combined and further cooled in water scrubbing tower before introduction to the compression system. Polymer and aromatic distillate are collected in the quench water surge drum and decanted there.

When the ethylene must be acetylene-free, the acetylene is selectively hydrogenated by passing the cracking heater effluent over a catalyst, generally after the second compression stage.

The combined heater effluent and fresh feed is compressed to approximately 500 psig, chilled, and dried over soild desiccants such as activated alumina or bauxite. The dryers consist of multiple desiccant chambers which are regenerated on a predetermined cycle.

The dried feed gas is further chilled and introduced into the deethanizer operating at 450 psig. Hydrogen, methane, ethane and ethylene are taken overhead and proplene, propane, and C_4 and heavier bottoms are charged to the depropanizer. The deethanizer overhead is then chilled by exchange and ethylene refrigeration to —130° F. The remaining vapor is further chilled to about —195° F. The condensed liquids are charged to the demethanizer. The residual vapor is expanded in a centrifugal expander to the fuel gas system pressure. The low temperature produced in the expander is used to produce the final cooling of the feed gas to —195° F.

The demethanizer overhead goes to fuel and the bottoms (recovered ethane and ethylene), is charged to the ethylene fractionator operating at about 60 psig. The ethylene fractionator is integrated with the ethylene refrigeration system for reflux and reboil heat. The ethylene product is taken overhead and the ethane bottoms are recycled to the ethane heater.

The depropanizer takes propylene-propane overhead and C_4 and heavier as bottoms. The propylene-propane is charged to the propylene fractionator operating at about 20 psig. Propylene products is taken overhead and propane bottoms are recycled to the cracking heater or withdrawn as LPG.

Refrigeration for the unit is supplied by centrifugal compressors operating in a cascade system.

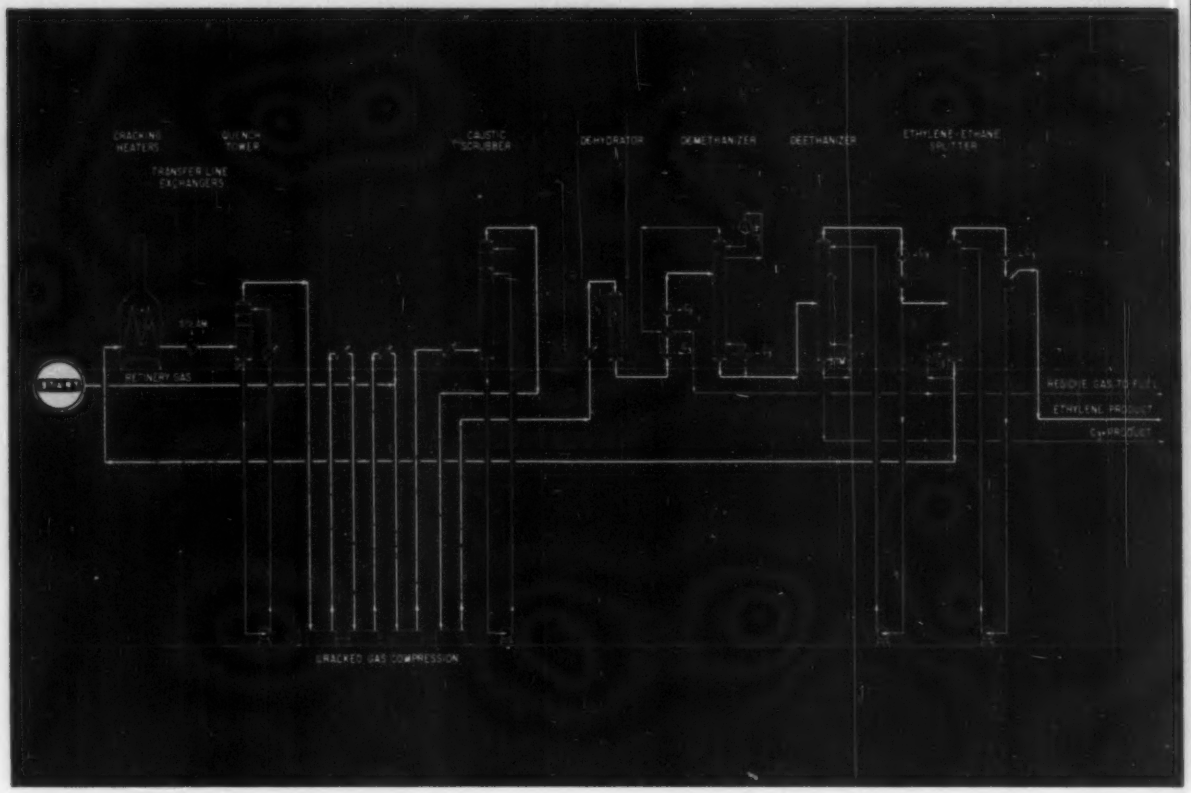
Yield: One million SCF of refinery feed gas gives yields as follows:

Refinery Gas	Volume Percent	Product Pounds
Hydrogen plus inert	7.4	———
Methane	28.5	———
Ethylene	9.9	32,200
Ethane	33.9	———
Propylene	3.3	7,800
Propane	13.4	———
C_4 and heavier	3.6	8,900
Fuel Gas	———	855,000 SCF

A modification of the fractionation system shown above permits the manufacture of ethylene and propylene from naphtha charge stocks. Ethylene of purities to 99.9+ volume percent may be produced with this system.

Commercial Installations: The Lummus Company has designed and constructed 14 units producing ethylene and/or propylene from various feed stocks.

Reference: PETROLEUM REFINER, July,'54,p135.



Ethylene Production—STONE & WEBSTER ENGINEERING CORPORATION

Application: A process for the production of ethylene from various distillate or gaseous feed stocks.

Charge: Naphtha, gas oil, refinery gas, ethane, propane, or butane may be charged.

Products: The primary product is high purity ethylene. Other products are:

- Residue gas, substantially hydrogen and methane.
- A liquid fraction which may be further fractionated.

Description: The recovery process utilized may be either low temperature fractionation or low temperature absorption, depending on the composition of the feed gas to the recovery section and the quantity of inerts. This description is based on low temperature fractionation with ethane cracking.

Refinery gas is combined with gas from the cracking furnaces and compressed to the pressure required by the demethanizer. This pressure will vary with the concentration of hydrogen and methane and the recovery of ethylene desired. The compressed gas is cooled, dried and fed to the demethanizer wherein methane and lighter components are taken overhead by fractionation at low temperature. Reflux is produced with ethylene refrigerant.

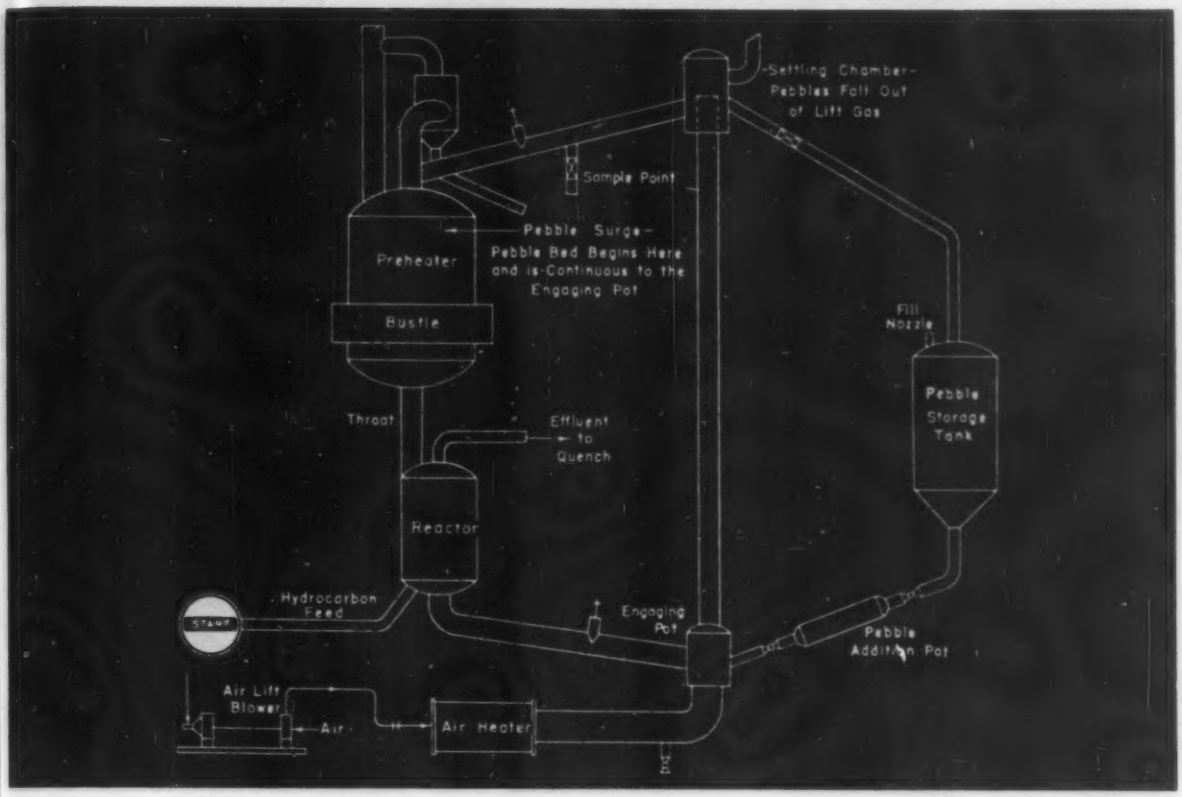
The demethanized bottoms flow to the deethanizer, from which ethylene and ethane are taken overhead, and propylene and heavier discharged as a bottoms stream. This stream may be further separated in a depropanizer, and the recovered propylene-propane cut processed for removal of propylene. The unreacted propane can then be returned to the ethylene unit and cracked to produce additional ethylene. The ethylene-ethane stream is fractionated at low temperature to produce an ethylene product of the required purity and an ethane stream which is vaporized and recycled to the cracking furnaces. Cracking is performed in a coil-type reactor designed for graduated heat intensity in conformity with a temperature gradient conducive to maximum ethylene yield and minimum coke formation. The furnace effluent is quenched and cooled in a quench tower in which heavy aromatic oil is condensed and separated.

Where an ethylene product with low acetylene content is required, the cracked gas, after compression to an intermediate pressure, is heated and selectively hydrogenated over a catalyst. The gas is then cooled, combined with the refinery gas fresh feed stream and compressed to the final discharge pressure. Refrigeration is by a propane-ethylene cascade system.

Yields: Ultimate yields of ethylene from cracking of C_2 and C_3 are approximately 77 and 45 percent by weight, respectively. Ethylene recovery ranges from 96 to 98 percent. Ethylene product purity normally is in the range of 95 to 99.9 percent.

Commercial Installations: Twenty-four plants with a combined production of over 5 million pounds per day of ethylene, and seven plants under construction.

Reference: PETROLEUM REFINER, July'54,p135.



Ethylene with Pebble Heater— PHILLIPS PETROLEUM COMPANY

Application: A heating process for attaining temperatures beyond the range of conventional tube furnaces.

Charge: The charge may be gaseous hydrocarbons, inert or corrosive gases, steam or air. It is primarily C_2 to C_4 hydrocarbons for ethylene manufacture.

Product: Ethylene and other unsaturated hydrocarbons, predominantly olefinic. However, the cracked hydrocarbon effluent depends on the processing conditions, i.e., reaction time, pressure and temperature.

Description: In the Pebble Heater process, continuously circulating refractory balls (pebbles) are contacted directly in a reaction chamber with the charge material to be heated or cracked. As shown by the flow diagram, a continuous bed of pebbles extends from the engaging pot upward through the reactor and preheater vessel into the pebble surge at the top of the preheater. This entire bed of pebbles slowly moves downward through the chambers at a rate controlled by a flow control device in the engaging pot. In the lift line the pebbles travel upward in a stream of heated air. The pebbles settle out of the lift air in an enlarged vessel at the top of the lift line and then run down the sloping line to the top of the bed in the pebble surge. As the pebble bed moves downward in the pre-heater, the pebbles are heated by an upward flow of hot combustion gases. These hot gases are generated under pressure in the bustle-type combustion chamber surrounding the lower portion of the preheater vessel. The hot pebbles then pass through a restricted throat into the reaction chamber where the upward-flowing gaseous charge is heated. The feed is admitted to the lower portion of the reactor through a distributor designed to minimize interference with the flow of pebbles. The resulting cooled pebbles flow downward out of the reactor through a duct into the engaging pot and are returned through the lift to the settling chamber. When processing hydrocarbons the heated gases pass out the top of the reactor into a quench vessel where the temperature may be quickly lowered by direct water spray.

To prevent the undesirable mixing of combustion gases and reactor effluent, a pressure balance is maintained across the throat between the preheater and the reactor. Further to insure separation of the gases, steam is injected into the throat between the chambers. Between the reactor and the engaging pot a steam seal is used to separate the lift gas from the reactor feed.

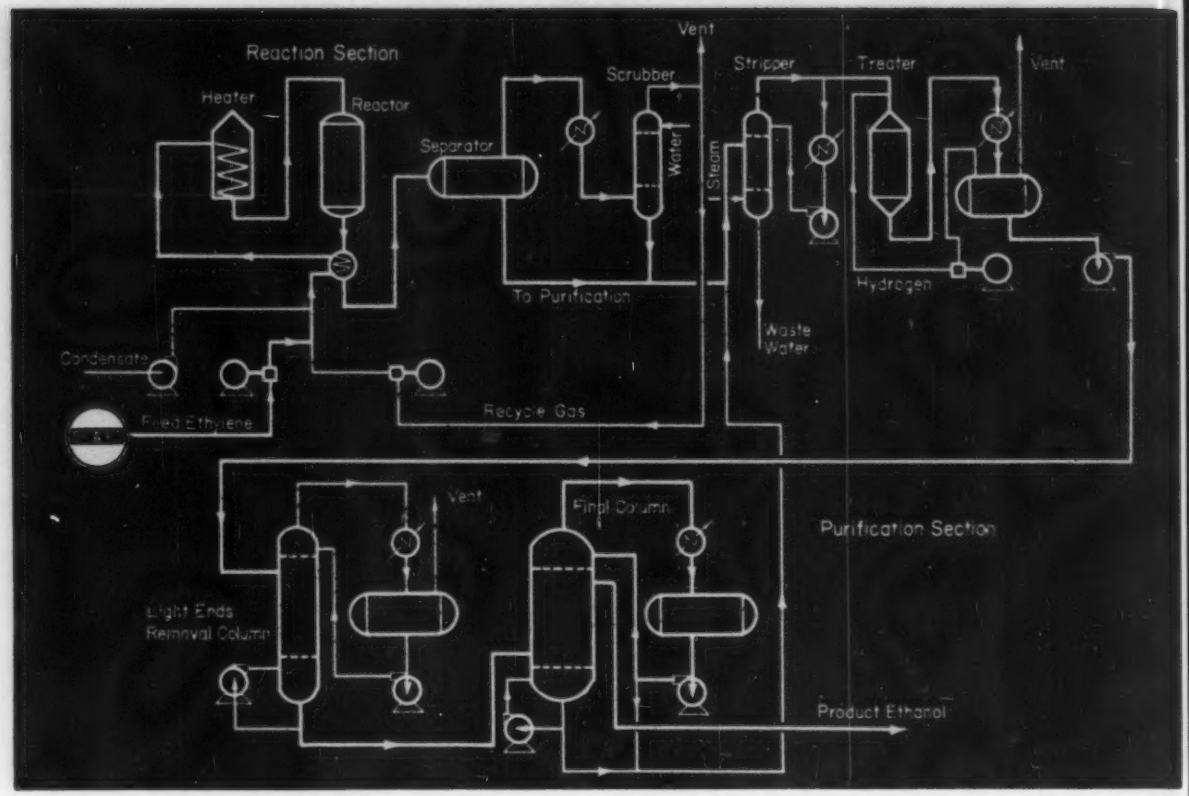
Operating Conditions: The major operating variables for hydrocarbon processing are temperature, pressure and reaction time. For other materials not all of these variables may be significant.

Yields: Typical feed stock and corresponding reactor effluent compositions are as follows:

Feed	(Mol. Percent)	Reactor Effluent	(Mol. Percent)
		Hydrogen	45.0
Ethane	91.0	Methane	7.6
Propane	8.9	Acetylene	3.8
Other	0.1	Ethylene	33.3
		Ethane	7.0
	100.0	Heavy Unsaturates	3.3
			100.0

Commercial Installations: Following several years of successful pilot plant operation, Phillips has installed a 30 MM Btu per hour commercial Pebble Heater at Borger, Texas.

Reference: PETROLEUM REFINER, Apr.'54, p171.



Ethyl Alcohol— SHELL DEVELOPMENT COMPANY

Application: A process for the manufacture of ethanol.

Charge: Ethylene gas (97 percent purity) and water vapor.

Products: Ethanol 95 volume percent purity.

Description: The reaction section shown is only one of several parallel units making up the plant. The feed ethylene is compressed to approximately 1,000 psi in the feed compressor. This stream is combined with the recycle stream from the recycle gas compressor and joined by a controlled stream of water in the ratio of 0.6 moles of water per mole of ethylene. This stream is pre-heated by exchange with the reactor product and totally vaporized in a gas fired furnace and heated to a final temperature of 570° F before going into the top of the reactor.

The feed passes downward through the catalyst bed (phosphoric acid supported on diatomaceous earth) and a fraction of the ethylene and water is converted to ethyl alcohol on each pass through the reactor. Since the reaction is exothermic, products leave the reactor at slightly higher than the feed temperature.

The reactor product is exchanged with feed, neutralized with caustic soda and separated into liquid and vapor in a high pressure separator. The liquid product goes to the purification section. The vapor is cooled in the recycle gas cooler and scrubbed to remove ethanol. This ethanol-water mixture is sent to the purification section and the gas from the scrubber is recycled. Some of the recycle gas is vented to the ethylene plant to limit concentration of ethane and methane in the reactor feed.

The crude product from the several parallel reactor streams is combined and separated in a low pressure separator. This crude stream is steam stripped, the bottoms going to waste, and the overhead going to the treater. In the treater, the crude stream is combined with a recycle hydrogen stream and, over a nickel catalyst, the trace amounts of aldehydes are converted to the corresponding alcohols.

In the final purification section the light-ends column removes light byproducts, principally diethyl ether, and the final column purifies the ethanol.

Reactions: In the Shell hydration process, ethylene and water combine chemically by the reaction:

$$C_2H_4 + H_2O \xrightarrow{H_3PO_4} C_2H_5OH + 19{,}000 \text{ BTU/LB. Mole}$$

The primary side reaction forms diethyl ether by dehydration of ethanol:

$$2\,C_2H_5OH \xrightarrow{\text{Catalyst}} (C_2H_5)_2O + H_2O$$

Acetylene, present as an impurity in the feed ethylene, forms acetaldehyde:

$$C_2H_2 + H_2O \xrightarrow{\text{Catalyst}} CH_3CHO$$

In addition, a small amount of ethylene polymerizes to form less than one percent of a wide range of olefinic polymers.

The hydrogenation reaction converts the aldehydes to alcohols over a nickel catalyst. In this way acetaldehyde is converted to ethyl alcohol:

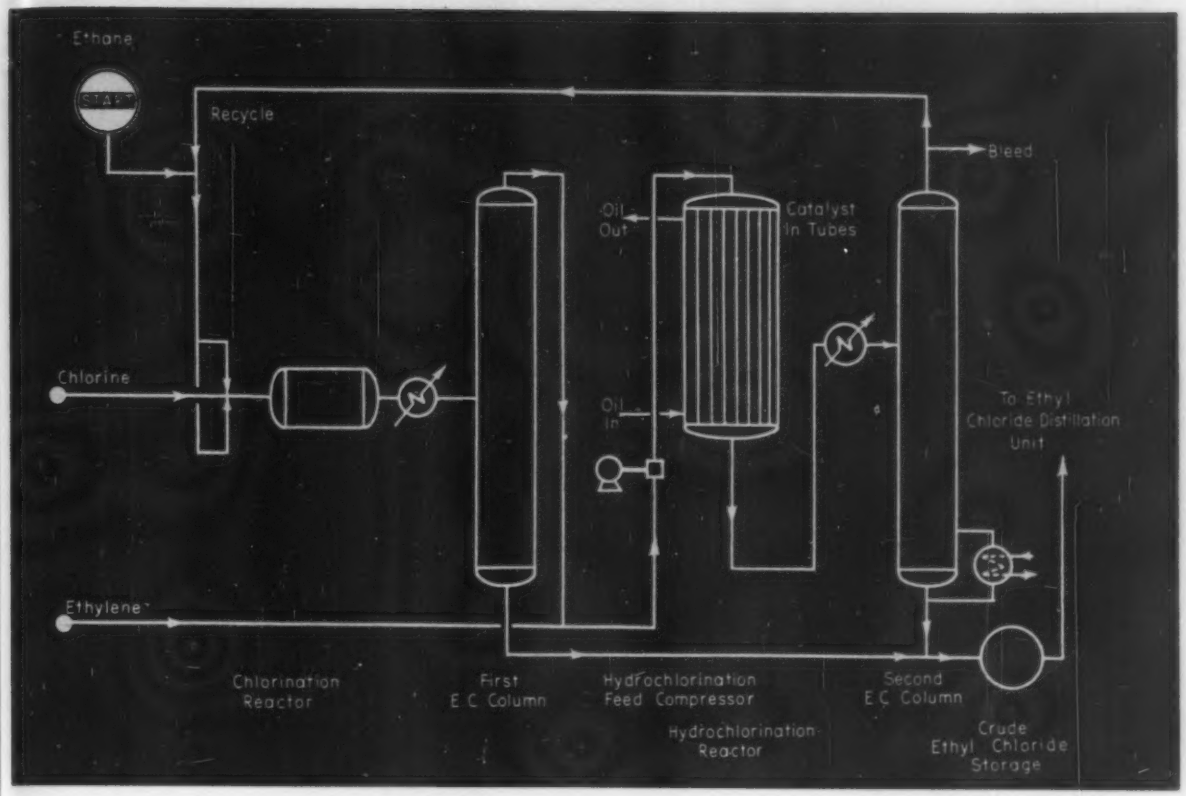
Operating Conditions: The conditions for the ethylene hydration reaction are as follows:

Reaction temperature	570° F.
Reaction pressure	1000 psig.
Reactor feed ethylene concentration, water free basis	85 percent
Ethylene make-up concentration	97 percent
Space velocity, VSVM	0.6
Ethylene conversion per pass	30
Water conversion	4.2 percent
Water-to-ethylene molal ratio in feed	7.0 percent

Yields: Over-all process yield, ethylene to alcohol, is 97 percent or better.

Commercial Installations: This process or a variation is used by Shell Chemical Company at Houston and by British Petroleum Chemicals, Ltd., at Grangemouth, Scotland.

Reference: *Chemical Engineering Progress,* Oct. '54.



Ethyl Chloride— SHELL DEVELOPMENT COMPANY

Application: A combination of substitutive chlorination of ethane and hydrochlorination of ethylene for the manufacture of ethyl chloride.

Charge: Ethane, chlorine and ethylene.

Products: Ethyl chloride.

Description: Chlorine, ethane, and a recycle gas stream which may contain ethylene are fed to the chlorination reactor. The combined ethane and recycle are pre-heated. The chlorine enters as a vapor. The reaction is exothermic and is carried out adiabatically. The reactor exit stream is cooled and sent to the first ethyl chloride column where the inerts, unreacted ethane, hydrogen chloride and some of the ethyl chloride are taken overhead. The remainder of the ethyl chloride and other chlorinated by-products leave as bottom product and are sent to crude ethyl chloride storage.

The overhead stream from this first column plus fresh ethylene is compressed, preheated and fed to the hydrochlorination reactor, where 50-80 percent of the ethylene and the hydrogen chloride combine. In this reaction, temperature is a more important variable than it is in chlorination, and the reaction is carried out isothermally, heat being removed by circulating oil.

The hydrochlorinator exit stream is cooled and fed to the second ethyl chloride column where crude ethyl chloride is taken out as bottoms and sent to crude ethyl chloride storage. The overhead consisting of ethane, inerts, unreacted ethylene and hydrogen chloride is recycled to the chlorinator. It is necessary to vent a portion of this stream to prevent buildup of inerts. The crude ethyl chloride is fed to the ethyl chloride distillation unit, where it is purified in a straight-forward manner by passing first through a heavy-ends column and then through a light-ends column.

In the chlorination reaction, the chlorine disappears completely. Some of the ethylene reacts, but some ethylene is formed by ethyl chloride cracking. Moles of HCl formed exceed slightly the moles of chlorine fed.

In the hydrochlorination reaction the addition of fresh ethylene to the gas stream from the first ethyl chloride column is automatically controlled so that the ethylene-to-hydrogen chloride feed ratio is 1:1. This ratio is not critical, but 1:1 appears to be optimum. Since one mole of ethylene reacts with one mole of hydrogen chloride, the ethylene-hydrogen chloride ratios in the reactor exit, recycle, and vent gas streams are also 1:1.

Reactions: The ethane chlorination reaction in this process is carried out in the presence of ethylene at or above 750° F. It produces ethyl chloride and hydrogen chloride:

$$Cl_2 + C_2H_6 \rightarrow C_2H_5Cl + HCl$$

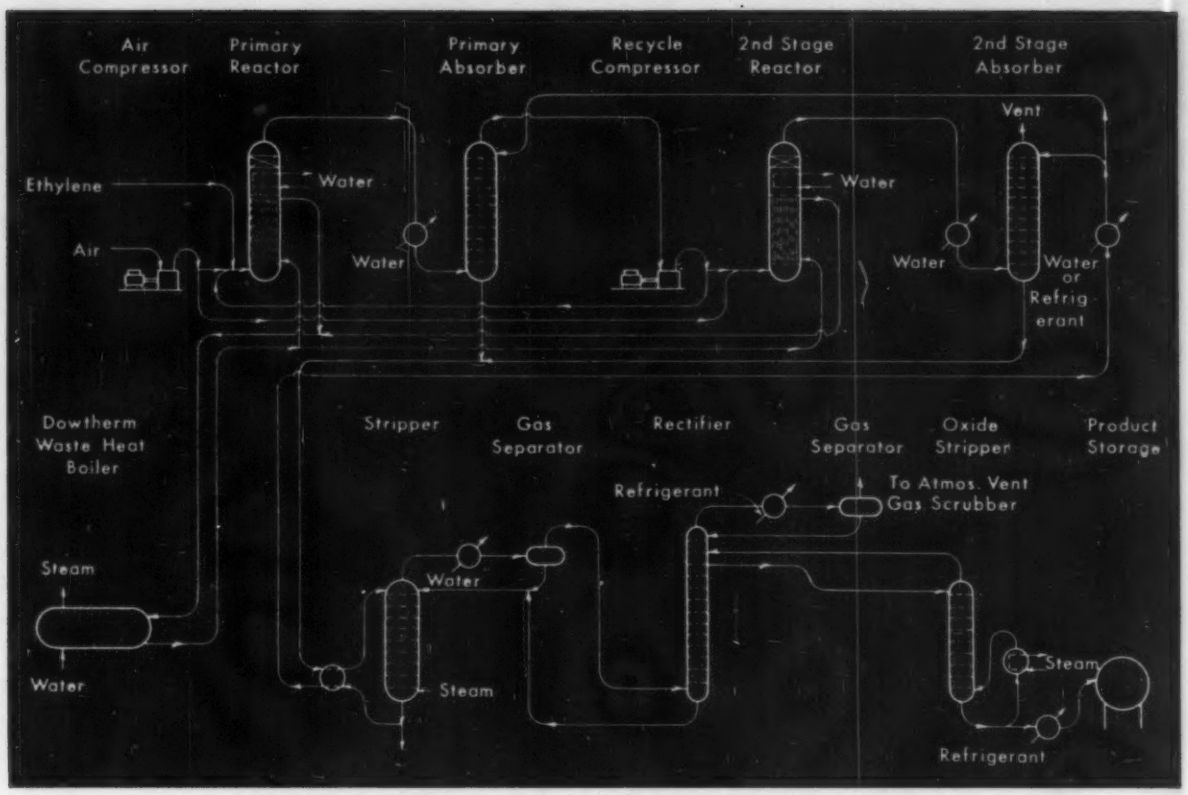
The hydrogen chloride produced in the chlorination reaction is used in the ethylene hydrochlorination reaction which is carried out in the vapor phase at elevated pressure in a reactor packed with catalyst:

$$HCl + C_2H_4 \rightarrow C_2H_5Cl$$

Yields: 90 percent over-all yield, ethane plus ethylene to ethyl chloride, and 95 percent chlorine to ethyl chloride.

Commercial Installation: Associated Ethyl Co., Ltd., Ellesmere Port, Cheshire, England.

Reference: *Industrial and Engineering Chemistry,* Vol. 47,No.5,May'55. U.S. Patent No. 2,807,656 (Sept. 24, 1957).



Ethylene Oxide— THE ATLANTIC REFINING CO.—VULCAN-CINCINNATI, INC.

Application: A process for making ethylene oxide.

Charge: Ethylene of 95+ percent purity.

Product: Ethylene oxide of 99.5 percent purity.

Description: Ethylene oxide is made by the direct oxidation of ethylene. Ethylene and air are mixed with recycle gas and passed through a multitube reactor, each tube of which is filled with a fluidized silver catalyst. The tubes are kept full by a layer of catalyst held above the tube sheet. Specially designed orifices assure equal gas distribution. A dowtherm system removes the heat of reaction and gives the required close temperature control. The dowtherm vapors when condensed form steam for the process. The reaction is quenched right after the catalyst bed by internal cooling coils. Filters remove any entrained catalyst from the gases. After further cooling the gases flow to the primary absorber where they are scrubbed with water to extract the ethylene oxide.

The oxide-free gas is recompressed. Part of the stream is recycled to the primary reactor, and part, with a small amount of air added, is fed to the second stage reactor. This reactor, of the same design as the primary, is operated on a once through basis. Exit gases are cooled and then scrubbed with water in the second stage absorber. The oxide-free gas may be vented or go to a third stage.

The absorbates from the two absorbers are combined and fed to the top of a bubble-cap stripping column after heat exchange with the bottoms-stripped absorbent from the stripper. Stripped absorbent is returned to the absorbers. In the stripper column ethylene oxide and other gases are stripped from the absorbate by open steam. A mixture of ethylene oxide, water and carbon dioxide goes overhead to a partial condenser where water is separated and refluxed to the stripper.

The uncondensed vapors are fed to a rectifying column. The bottoms stream is returned to the stripper as reflux. The overhead stream is partially condensed. The condensate is refluxed, and the uncondensed gases are sent to an atmospheric vent gas scrubber for recovery of any ethylene oxide present in the gas.

A sidestream from the column, containing the ethylene oxide product and carbon dioxide, is fed to the oxide stripper where the carbon dioxide is removed overhead. This stream is returned to the rectifying column, and the bottom stream, the ethylene oxide product, is cooled and sent to storage in spheres under inert gas.

The catalyst is a specially prepared silver catalyst with good fluidization characteristics. No regeneration or reactivation of the catalyst is needed, and in the captive fluid bed no attrition problem has yet appeared. The reactions involved are simple.

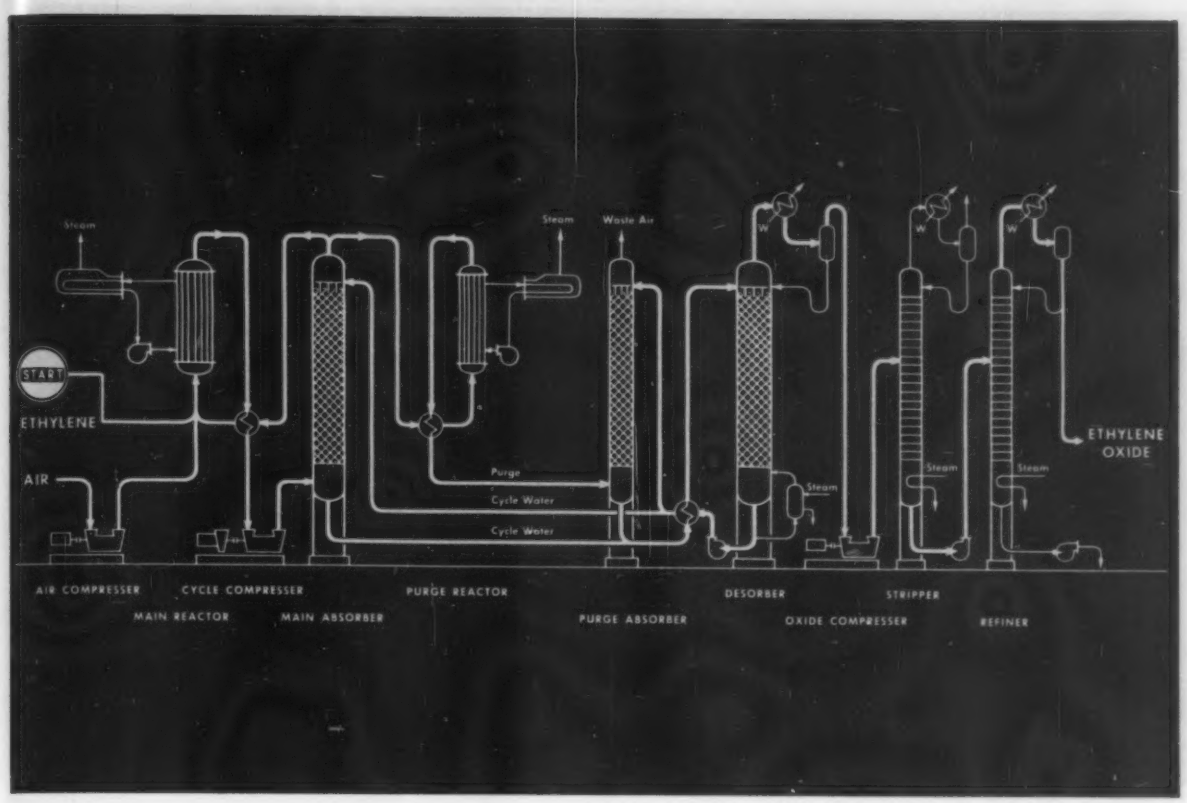
(1) $$C_2H_4 + \tfrac{1}{2}\,O_2 \rightarrow C_2H_4O$$

(2) $$C_2H_4 + 3\,O_2 \rightarrow 2CO_2 + 2H_2O$$

High temperatures favor reaction (2), and close temperature control is necessary to avoid local hot spots.

Operating Conditions: Reaction temperatures are 400° to 600° F. Pressures are 100 to 150 psig.

Yields: The over-all yield of ethylene oxide is 55-65 percent, based on ethylene. At the present the economic yield is closer to 55 percent. Conversion in the primary reactor is 35-50 percent and in the second 50-70 percent.



Ethylene Oxide— SCIENTIFIC DESIGN COMPANY, INC.

Application: A process for the manufacture of ethylene oxide.

Charge: High purity ethylene and air.

Product: High purity ethylene oxide, liquid.

Description: Compressed air, ethylene, and recycle gas are mixed and fed to a multi-tubular, catalytic reactor. The temperature of oxidation is controlled by an organic cooling medium which is omitted on the process flow diagram. From the reactor the effluent gasses, which contain ethylene oxide, are cooled and further compressed. The cooling is accomplished first by recuperative exchange with the recycle gases, and finally by a water cooled exchanger. The gases then pass to a scrubber where ethylene oxide is absorbed in a dilute aqueous solution. Most of the unabsorbed gases are returned to the reactor via the previously mentioned recuperative exchanger, thus completing a closed circuit. A portion is diverted to the secondary reactor, to purge accumulated inert gases. The secondary reactor operates to scavenge the remaining ethylene. From the secondary reactor the effluent gases are cooled as before. The ethylene oxide is absorbed in a scrubber, and the residual gases are discharged from the system.

The dilute solution of ethylene oxide is stripped by heat. A feed-bottoms exchanger is usually employed to save steam. The overhead vapor, which contains a substantial amount of water vapor, may be passed through a partial condenser for enrichment. This partial condenser is omitted on the flow diagram, because it is not essential and because of space limitations. Oxide vapor is compressed and refined in a distillation train. There are several alternate arrangements for the distillation. As shown here, the carbon dioxide and other light ends are first stripped out of the oxide, and then pure oxide is distilled away from water and other heavier liquids. The pure ethylene oxide product is pumped as a liquid to storage tanks which are padded with inert gas.

The catalyst contains silver. Its long life and durability make catalyst costs a relatively unimportant item in the ethylene oxide manufacturing budget. The reactions involved are simple:

$$(1)\quad C_2H_4 + \tfrac{1}{2}O_2 \rightarrow C_2H_4O$$

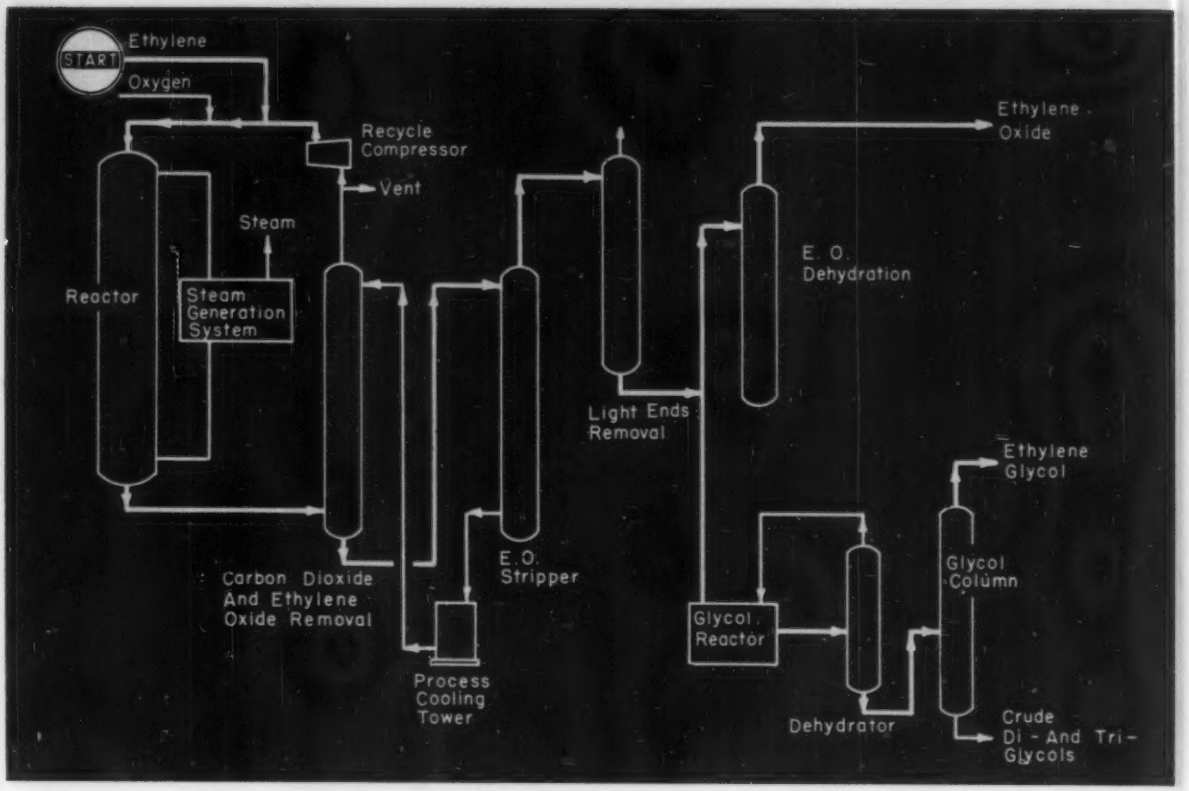
$$(2)\quad C_2H_4 + 3\,O_2 \rightarrow 2\,CO_2 + 2\,H_2O$$

Operating Conditions: Oxygen and ethylene concentrations in the reaction gases are quite critical. In order to avoid explosion hazards, they must be maintained at a low level. Reaction temperatures range between 450° and 600° F. The reaction pressure may vary between 120 and 300 psig. Distillation conditions are usually determined by the available cooling water temperature.

Yields: The weight yield, expressed as pounds of ethylene oxide produced per pound of ethylene consumed, approaches one hundred percent, in plants of the proper design.

Commercial Installations: Nine companies now have completed or in design, 16 units in five countries: Naphtachimie, Lavera, France (three expansions); Allied Chemical Corporation, Nitrogen Division, Orange, Texas; Societe Chimique des Derives du Petrole, Antwerp, Belgium (now being expanded); Badische Anilin-&-Soda-Fabrik (through its subsidiary Chemische Fabrik Holten G.m.b.H., Ludwigshaven, Germany); General Aniline and Film Corporation, Linden, New Jersey; Mitsui Petrochemical Industries, Ltd., Iwakuni City, Japan (now doubling original installation); Farbenfabriken Bayer (through its subsidiary Erdoelchemie G.m.b.H., Dormagen, Germany, now being expanded); Marles-Kuhlmann, Gonfreville, France; Jefferson Chemical Company, Port Neches, Texas; Mitsubishi Petrochemical Company, Ltd., Yokkaichi, Japan.

References: PETROLEUM REFINER, Sept. '53,p146; *Chemical Engineering*, Aug. '54,p130, July 28, 1958.



Ethylene Oxide and Glycol— SHELL DEVELOPMENT COMPANY

Application: The process produces ethylene oxide by direct oxidation of ethylene with 95 percent oxygen. Product distribution between ethylene oxide and glycol can be varied over a wide range.

Charge:

Ethylene		Oxygen	
Ethylene	98% min.	Oxygen	90-95%
Methane	1% max.	Nitrogen	Balance
Ethane	1% max.	Argon	
Acetylene	10 ppm max.		

Products: Ethylene oxide (99.7 percent min.) and ethylene glycol (99.6 percent min.) Description: Ethylene and oxygen together with recycle gas are charged to a tubular isothermal reactor. The reaction takes place in the presence of a silver catalyst and proceeds according to the equation:

$$C_2H_4 + \tfrac{1}{2}\, O_2 = C_2H_4O$$

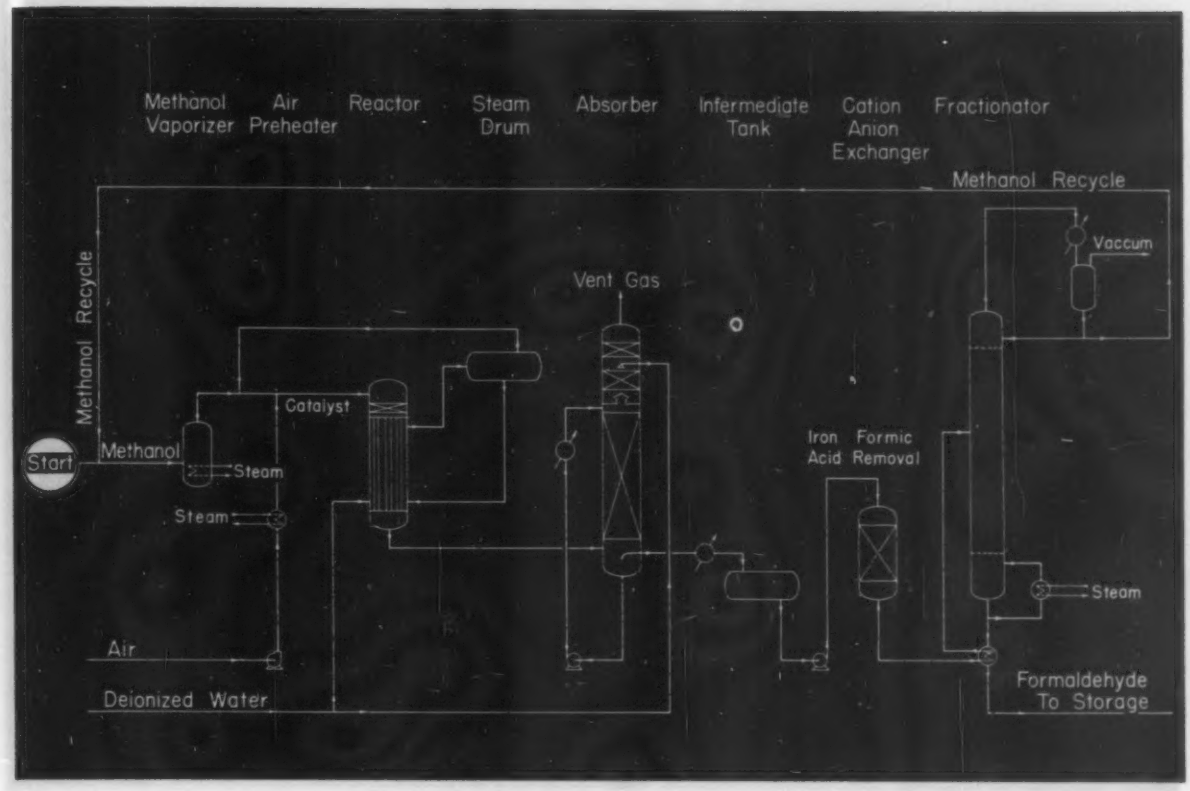
The heat of reaction is removed by a coolant, and the hot coolant is used to generate steam.

Ethylene oxide is recovered from the reactor effluent by absorption in water. Except for a small vent, the residual gases are compressed and recycled. The ethylene oxide is stripped from the "fat" water and distilled to remove light ends. The "lean" water is cooled in a process cooling tower before being returned to the absorber. Part of the raw ethylene oxide is dehydrated to produce finished ethylene oxide; the balance is reacted with excess water in a special reactor according to the equation:

$$C_2H_4O + H_2O = HOC_2H_4OH$$

The resulting aqueous solution of ethylene glycol is dehydrated to produce anti-freeze grade ethylene glycol; industrial grade ethylene glycol and diethylene glycol also may be produced.

Commercial Status: Petrochemicals, Ltd., Manchester, England; Petroleum Chemicals, Inc., Lake Charles, La.; and Wyandotte Chemicals Corporation, Geismer, La. The process is available through the following contractors: Badger Manufacturing Co., Catalytic Construction Co., The Fluor Corp., Ltd., The M. W. Kellogg Co., The Lummus Company, and Stone and Webster Engineering Corporation.



Formaldehyde (Uhde) — ARTHUR G. McKEE & COMPANY

Application: A process for producing synthetic formaldehyde.

Charge: Anhydrous methanol.

Product: Formaldehyde solution of 30-45 percent concentration.

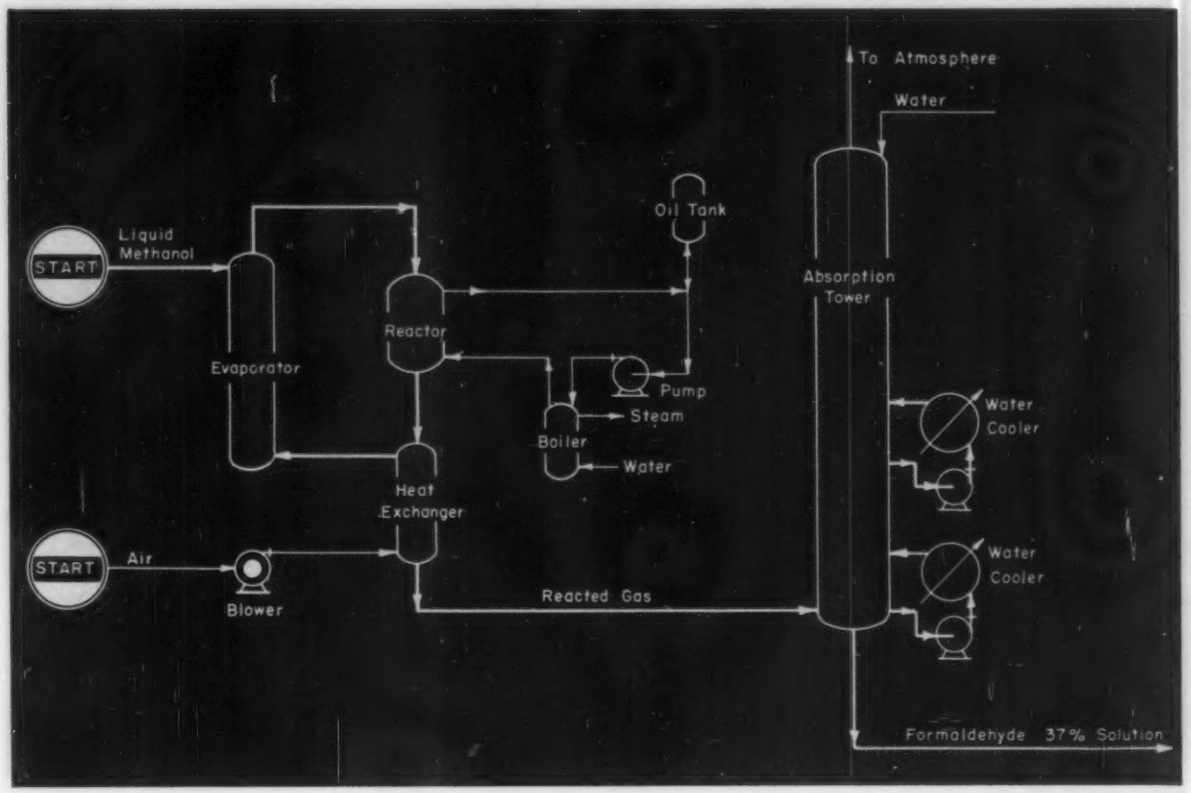
Description: Anhydrous methanol is vaporized and mixed with warm air and steam in controlled proportions. The mixture passes through a reactor where the methanol is converted to formaldehyde over a silver catalyst. The process is exothermic, and the reaction temperature is controlled from measuring points located in the catalyst bed. The lower part of the reactor vessel serves as a steam generator where the heat reaction produces the steam required for the reactor charge.

The reaction products are fed to the bottom of an adsorber where they are contacted with deionized water in the quantity necessary to produce the desired formaldehyde concentration.

The raw formaldehyde from the adsorber contains approximately 5 percent unconverted methanol and a small amount of formic acid. The formic acid is removed by ion exchange in the single cation-anion exchanger. The methanol content of the product may be removed in the following distillation column which operates under vacuum. The recovered methanol is recycled to the reactor section. The final purified formaldehyde normally contains only about 1 percent methanol.

Operating Conditions: The catalytic oxidation of methanol to formaldehyde is carried out at pressures slightly above atmospheric. The reaction temperature is varied between 930° and 1,185° F, depending upon the required concentration of the formaldehyde solution.

Yield: The over-all yield is high. When 37 percent formaldehyde containing 6 percent methanol is produced, the yield ranges from a minimum of 88 percent up to 90 percent.



Formaldehyde— MONTECATINI

Application: A process for the manufacture of formaldehyde solution, based on vapor phase catalytic oxidation of methanol by air.

Charge: Rectified methanol and atmospheric, non-purified air.

Product: Formaldehyde aqueous solution, 37 percent by weight, containing less than 1 percent by weight of methanol and less than 0.010 percent by weight of formic acid as impurities.

Description: Air, compressed at about 4.50 psig, is preheated in a heat exchanger in which heat from the reacted gases is recovered, and is then conveyed to a methanol evaporator.

The air-methanol gaseous mixture flows into reactor where, in the presence of a special oxidation catalyst, composed of metallic oxides, the following basic reaction takes place:

$$2CH_3OH + O_2 \rightarrow 2CH_2O + 2H_2O + 38.06 \text{ Kcal/gmol.}$$

The reaction temperature is controlled to strict limits by a thermostatic oil circulation system. Oil absorbs heat from the reactor and is then cooled in a boiler where the reaction heat is recovered in the form of high pressure steam (280 psig); after cooling, oil is recycled in closed circuit to reactor.

The reacted gases, containing formaldehyde vapors, nitrogen and steam flow through the air preheater and then reach a multistage absorption tower.

This is fed from the top with water. The absorption heat is removed by means of formaldehyde aqueous solutions circulated in a closed circuit, in the first two stages of the tower. Said solutions are cooled in heat exchangers located outside the tower.

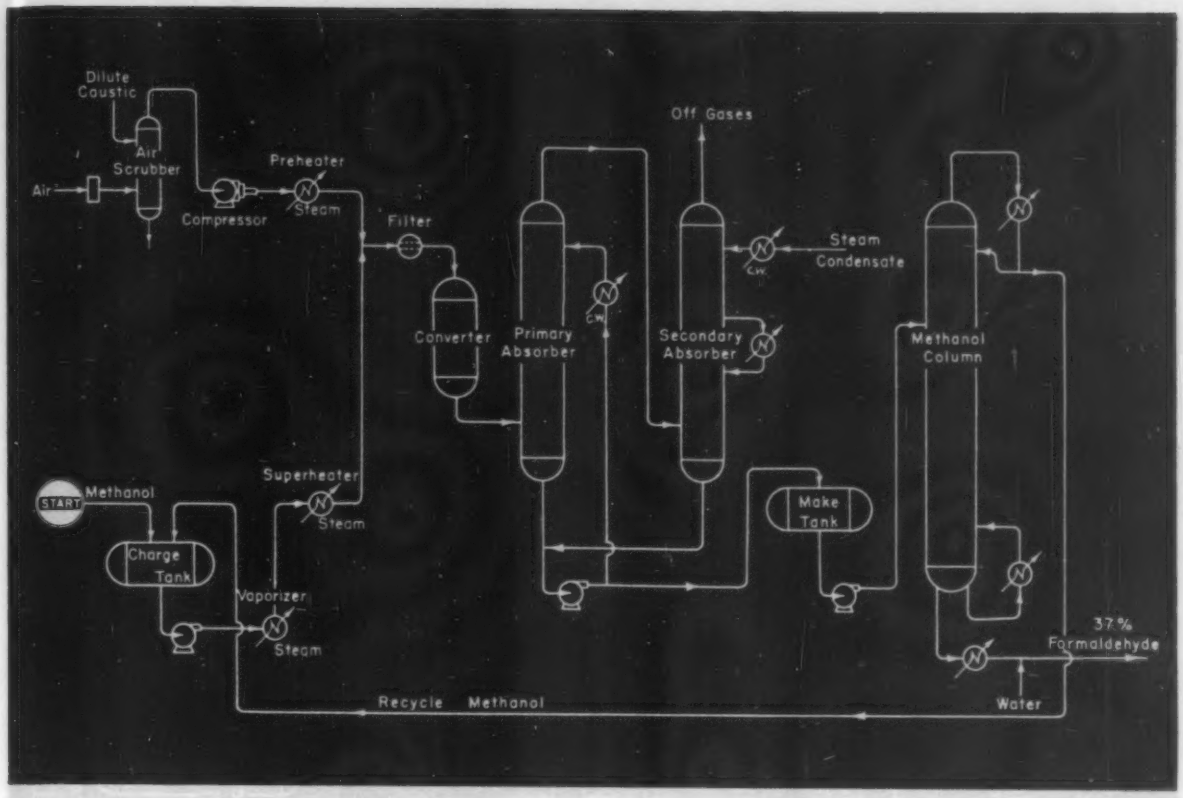
The formaldehyde solution produced is directly conveyed to storage tanks and does not need final distillation of excess methanol nor reduction in formic acid content since the process is adjusted to give a high quality product.

Operating Conditions: Complete safety against explosion dangers in the gaseous air-methanol mixture is obtained by a suitable choice of mixture components ratio. Up-to-date control equipment is widely used, so that only one man per shift is needed in running the plant.

Yields: Over-all yield based on methanol fed is higher than 90 percent on a stoichiometric basis. Heat recovering yields high pressure steam (280 psig), reaching 0.35 metric ton per ton of product.

Commercial Installations: A large industrial plant, composed by three units and having a total capacity of 135 million lb/year of 37 percent solution is in operation at Montecatini Works of Castellanza, near Milan, Italy.

Reference: *Chem. & Eng. News,* May 26,'58,p58.



Formaldehyde and Acetaldehyde

Application: A process for manufacturing formaldehyde from methanol or acetaldehyde from ethanol.

Charge: Methanol, 99.8 percent purity and atmospheric air for formaldehyde production. Ethanol and atmospheric air for acetaldehyde production.

Product: Either formaldehyde, 37 weight percent aqueous solution or acetaldehyde, 99 percent purity is produced, depending on the charge.

Description: *Formaldehyde.* Fresh and recycle methanol is vaporized, superheated and then passed to the methanol-air mixer. Atmospheric air is purified, compressed and then preheated to 130° F in a finned exchanger.

Methanol and air are mixed in approximately equal volumetric proportions and are fed to the converter. The simultaneous reactions which occur are:

$$CH_3OH + 1/2\ O_2 \rightarrow HCHO + H_2O + 38\ \text{k-cal.}$$
$$CH_3OH \rightarrow HCHO + H_2 - 20\ \text{k-cal.}$$

The products emerge from the converter at about 1150° F. The converter is a small water-jacketed vessel which contains several layers of silver gauze catalyst. The operating pressure is 5-10 psig.

About 65 percent of the methanol is converted per pass. Oxygen conversion is essentially complete.

The reactor effluent containing about 25 percent formaldehyde is fed to two absorbers in series where cooling and separation occurs using a counter-current stream of methanol and formaldehyde. Rich solutions from both absorbers are combined and sent to the make tank.

The solution is pumped from the make tank to the methanol column where 99 percent methanol is separated overhead and recycled to the charge tank. The bottom stream from this tower is the product and contains from 1-7 percent methanol. Water is added to reduce formaldehyde concentration to 37 weight percent.

Acetaldehyde. Ethanol vapor at 320° F is mixed with air preheated to 400° F and passed over a silver gauze catalyst. Simultaneous oxidation-dehydrogenation takes place at 1000° F to produce acetaldehyde with a yield of 85-90 percent. Conversion per pass of ethanol is about 50 percent. The reactor effluenet passes to absorption towers in which alcohol and aldehyde are cooled and condensed by a countercurrent stream of dilute alcohol. The rich liquor is rectified in a series of two columns. In the first, 99 percent acetaldehyde is removed overhead. In the second, 95 percent alcohol is removed overhead and recycled to the reactor.

Yields: Over-all process yields of formaldehyde and acetaldehyde based on charge stock, are 85-90 and 85-95 percent, respectively.

Commercial Installations: This type of process or a variation is used at the following plants: Bakelite Corporation, Bound Brook, N. J.; Commerical Solvents Corporation, Agnew, Calif.; E. I. duPont de Nemours & Company, Perth Amboy, N. J. and Toledo, Ohio; Durez Plastics and Chemicals, Inc., North Tonawanda, N. Y.; Heyden Chemical Corporation, Garfield, N. J.; Monsanto Chemical Company, Springfield, Mass.; Rohm and Haas Company, Bristol, Pa.; Spencer Chemical Corporation, Calumet City, Ill.

References: Petroleum Refiner, Jan.'55,p147;Feb.'55,p129; Mar.'55,p201.

Propylene
START
Propylene Storage
Chlorine
Lime Slurry
Water
Dilute Caustic
Dryer
Propylene Preheater
Reactor
Condenser
Recycle Compressor
Cooler
Pre-Fractionator
REFLUX
HCl Absorber
WATER
HCl
HCl Scrubber
CAUSTIC
Recycle Propylene
Crude Allyl Chloride
Allyl Chloride
Light Ends Column
Light Ends
Allyl Chloride Column
Heavy Ends
Allyl Chloride Storage
Hypochlorous Acid Tower
Reactor
Separator
Reactor
Reactor
Epichlorohydrin
Evaporation
Evaporation
Salt
Epichlorohydrin Stripper
Steam
$CaCl_2$
Water
Reactor
Epichlorohydrin Fractionator
Heavy Ends
Epichlorohydrin Storage
Vacuum Distillation
Vac
H_2O
Steam
Residue
Finished Glycerol
GLYCEROL

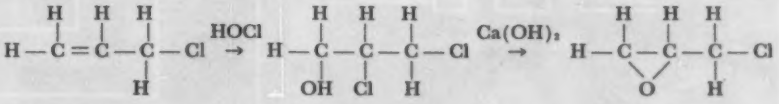
Glycerol (Epichlorohydrin)

Application: This process is for the manufacture of synthetic glycerol.

Charge: Propylene, 98 percent purity and chlorine 99+ percent purity are the charge.

Product: Glycerol (glycerine), 99+ percent purity, is the product.

Epichlorohydrin is produced from allyl chloride by the following reactions:



Description: For convenience, the synthetic glycerol process may be divided into three successive operations, the end products of which are allyl chloride, epichlorohydrin, and finished glycerol (termed "glycerine" in commercial practice). A portion of the allyl chloride produced is used in the manufacture of allyl alcohol. Similarly, a portion of the epichlorohydrin produced is used in the manufacture of epoxy resins.

Allyl chloride is produced by the hot chlorination of propylene. Substitution rather than addition of chlorine takes place. This is the most important step in the synthesis and the one which presented most difficulties in the original development.

Fresh liquid propylene is fed to a storage tank where it is blended with recycle propylene in a ratio of about 1:3. The blend is dried over a solid desiccant, preheated to 650°-700° F in a fired tubular heater, and mixed rapidly with cold chlorine gas. The reactor is a simple steel tube which is operated adiabatically. The reaction is exothermic and the products leave at 950° F. The ratio of propylene to chlorine in the feed is 4:1. Conversions of propylene and chlorine are about 25 percent and 100 percent, respectively. The yield of allyl chloride is 80-85 percent. The operating pressure is 15 psig. A certain amount of coking occurs and a multiple-unit arrangement allows periodic de-coking without disturbance of operating continuity.

The effluent gases are cooled quickly to 120° F. in a tubular exchanger and are sent to the prefractionator. Unconverted propylene plus hydrogen chloride are removed overhead. Reflux is dry liquid propylene at —40° F. The overhead gas is scrubbed first with water and then with caustic before being compressed, liquefied, and returned to charge propylene storage. A by-product stream of 32 weight-percent HCl is recovered from the water-scrubbing operation.

The bottoms stream from the prefractionator contains about 75 weight percent allyl chloride. Dichloropropane is the major contaminant. The dichloropropane stream finds commercial use as a nematicide. Purification is effected in two conventional fractionators. The first serves to remove the 1-2 percent light ends present in the crude allyl chloride and the second serves to remove dichloropropane and other high boilers. The purified allyl chloride is placed in storage for use in the manufacture of allyl alcohol and glycerol.

Chlorine and water are reacted in a tower to form a solution of hypochlorous acid which is in turn reacted with allyl chloride in a stirred tank to form a mixture of dichlorohydrins. The desired reaction takes place in the aqueous phase, and a minimum of allyl chloride is allowed in the reaction zone in order to avoid side reactions in the non-aqueous (allyl chloride) phase. The reaction is exothermic but readily maintained in the 85°-100° F range by the excess of acid.

The reactor effluent passes to a separator tank where the aqueous phase is removed and recirculated to the chlorinating tower. The non-aqueous phase, containing the mixture of dichlorohydrins, is fed to a stirred reactor where it is contacted with a lime slurry. The reactor contents are maintained below 140° F. Essentially complete conversion to epichlorohydrin is obtained. The product is steam-distilled at atmospheric pressure as a water azeotrope which contains in addition a small amount of unreacted dichlorohydrin. Epichlorohydrin of 98 percent purity is obtained from a final distillation.

Glycerol is formed by the hydrolysis of epichlorohydrin, using sodium hydroxide. Dilute (about 10 percent) caustic is added to the epichlorohydrin in a stirred tank. Essentially complete conversion to glycerol is obtained. The effluent from the tank is a dilute solution of glycerol containing sodium chloride. Salt and most of the water are removed in a multiple-effect exaporation system. At an intermediate point the salt crystallizes and is removed from the bottom of the evaporator. A certain amount of glycerol is recovered from the ensuing settling operation and is recycled to the evaporation system. Reduced pressure is used in the latter stages of the evaporation. Crude glycerol of about 90 percent purity is obtained.

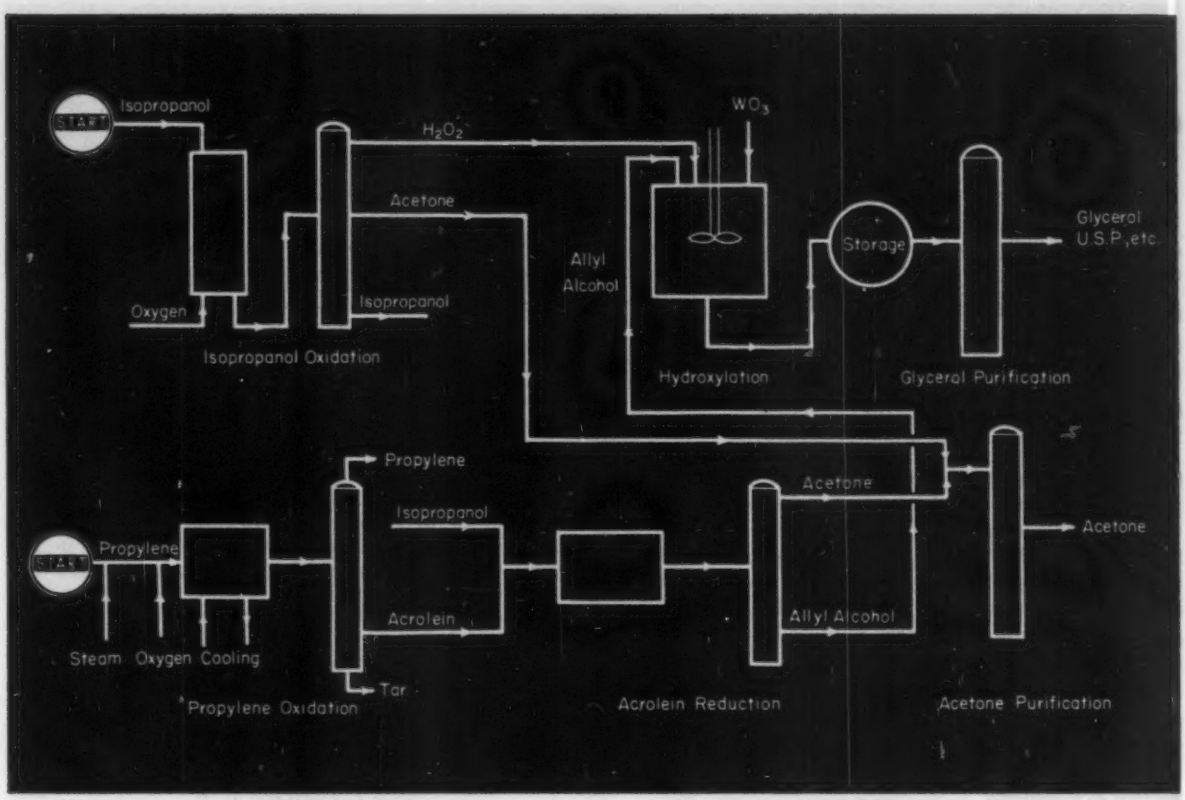
Glycerol of 99+ percent purity is obtained in a final vacuum distillation operation. It is stored in nickel-clad steel tanks and shipped from the plant in aluminum tank cars.

Operating Conditions: The key reaction in the glycerol synthesis is the hot chlorination of propylene. Typical operating conditions for this reaction are given in the above text.

Yields: Over-all process yield, glycerol from propylene and chlorine is 75-80 percent.

Commercial Installation: This process or a variation is used at Shell Chemical Company at Deer Park, Texas, Norco, La., and The Dow Chemical Company, Freeport, Texas.

References: Miner, C. S., and N. N. Dalton (Eds) Glycerol, *ACS Monograph*, No. 117, '54,pp80-83; *Chemical Engineering*, 55, No. 10, Oct. '48,pp134-137.



Glycerol (Acrolein and Hydrogen Peroxide)

Application: This is a process for the manufacture of glycerol with large amounts of acetone as a coproduct.

Charge: Propylene, Oxygen.

Description: Propylene is first hydrated to isopropanol using a standard process. (See Page 264). The isopropanol is oxidized in the liquid phase by bubbling pure oxygen through a liquid mixture of isopropanol and H_2O_2 at a pressure of about 2.5 atmospheres and at temperatures between 90° and 140° C. The reaction mixture is diluted with water, stabilized, and fractionated to yield hydrogen peroxide solution, acetone and unreacted isopropanol, which can be recycled.

A mixture of propylene with slightly more than an equal amount of steam is reacted with 25 percent oxygen based on the weight of the propylene. The reaction is carried out over a fixed bed of catalyst based on cuprous oxide, supported on SiC or some other high thermal conductivity support. Close control of reaction temperature is necessary. The reaction pressure may be from 1 to 10 atmospheres and the temperature between 300° and 400° C. The reaction mixture is cooled and fractionated to give acrolein, unreacted propylene, and tarry by-products. The yield of acrolein is near 86 percent of the propylene consumed.

The purified acrolein is mixed with pure isopropanol from the propylene hydration step and the mixture vaporized. The mixed vapors containing 2-3 moles of alcohol per mole of acrolein are passed through a catalyst bed containing both uncalcined magnesium oxide and zinc oxide, with the magnesia predominating. The reaction takes place at about 400° C and yields about 77 percent allyl alcohol (based on acrolein charged) and an additional quantity of acetone which is added to that formed in the isopropanol oxidation step.

Purified ally alcohol is agitated with a water solution of hydrogen peroxide containing a small amount of tungsten trioxide in solution. The effective catalyst is a 0.2 percent pertungstic acid solution in 2 molar aqueous hydrogen peroxide. The reaction temperature is 60°-70° C, reaction time is about two hours, producing glycerol in water solution.

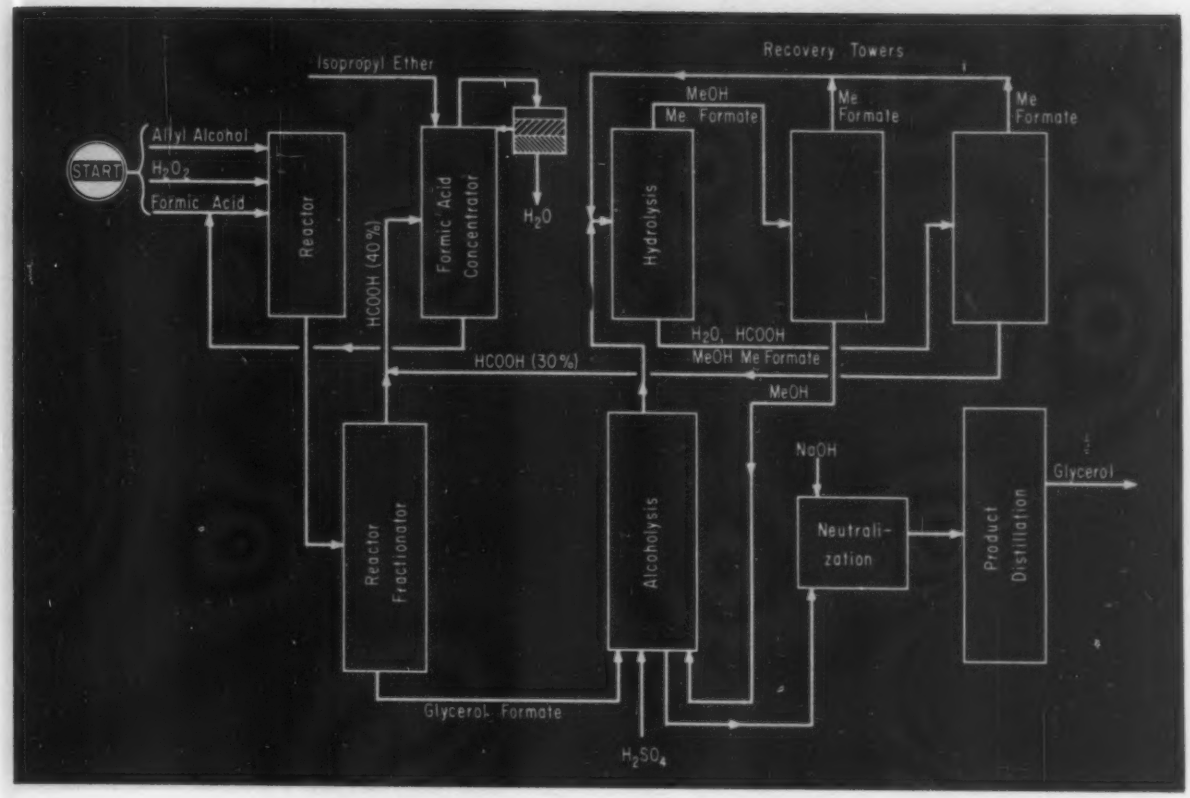
The reaction mixture is dumped to receivers and distilled to yield high-purity glycerol. The recovered catalyst solution is recycled. The yield of the final step 80-90 percent based on the allyl alcohol charged.

Operating Conditions: The control of both the propylene oxidation step and the hydroxylation step must be exceptionally good for acceptable yields. The conditions quoted are approximate, and the practical operating limits are doubtless much less broad.

Yields: The over-all yield of useful products (glycerol and acetone) is not known. The over-all glycerol yield on propylene charged to the oxidation is in the range of 50-60 percent.

Commercial Installations: All units for the process have been installed by Shell Chemical Co., Norco, La., except the final conversion to glycerol. This last unit is under construction for early 1960 startup.

References: Glycerol Payoff in Propylene Parlay, *Chemical Week*, May7,'55,p72-77; S. A. Ballard, H. deV. Finch and E. A. Peterson (to N. V. Bataafsche Petroleum Maatschappij), British Patent 619,014, Mar.2,'49; M. Mugdan and D. P. Young, *J. Chem. Soc.*, 49,2988-3000,CA:43-5269h.



Glycerol (Formic Acid)

Application: This is a process for the manufacture of synthetic glycerol.

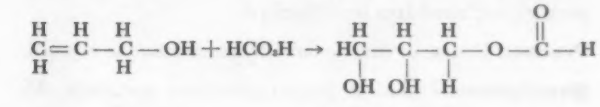
Charge: Allyl alcohol, formic acid (95 percent), methanol.

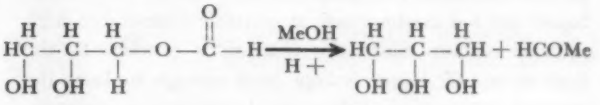
Product: Glycerol 99+ per cent purity.

Description: Allyl alcohol produced from allyl chloride (see Glycerol, Epichlorohydrin) is fed to a continuous reaction chamber along with formic acid and hydrogen peroxide. Holding time in the reactor is about one hour at 46° C. The reaction mixture continuously overflows to a fractionation tower from which 50 percent formic acid is taken overhead to recovery. The bottoms from this tower pass to the alcoholysis reaction. Methanol is added and reacts, in the presence of a small amount of H_2SO_4, to produce methyl formate which vaporizes under the conditions of the reaction, leaving crude glycerol as a residue. The crude product is neutralized with caustic, washed, and distilled to produce a 99+ percent purity product for sale.

In the recovery system, methyl formate is hydrolized with acid catalyst, producing a hydrolysis product containing methanol, formic acid, water, and unhydrolized methyl formate. This mixture is distilled to recover dilute formic acid, concentrated methanol, and recycle methyl formate. The dilute formic acid is concentrated by azeotropic distillation with isopropyl ether and recycled to the beginning of the process.

The reactions involved in this process are hydroxylation, ester interchange, and hydrolysis. The most probable effective reactant in the first reaction is performic acid, leading to the following series of reactions:



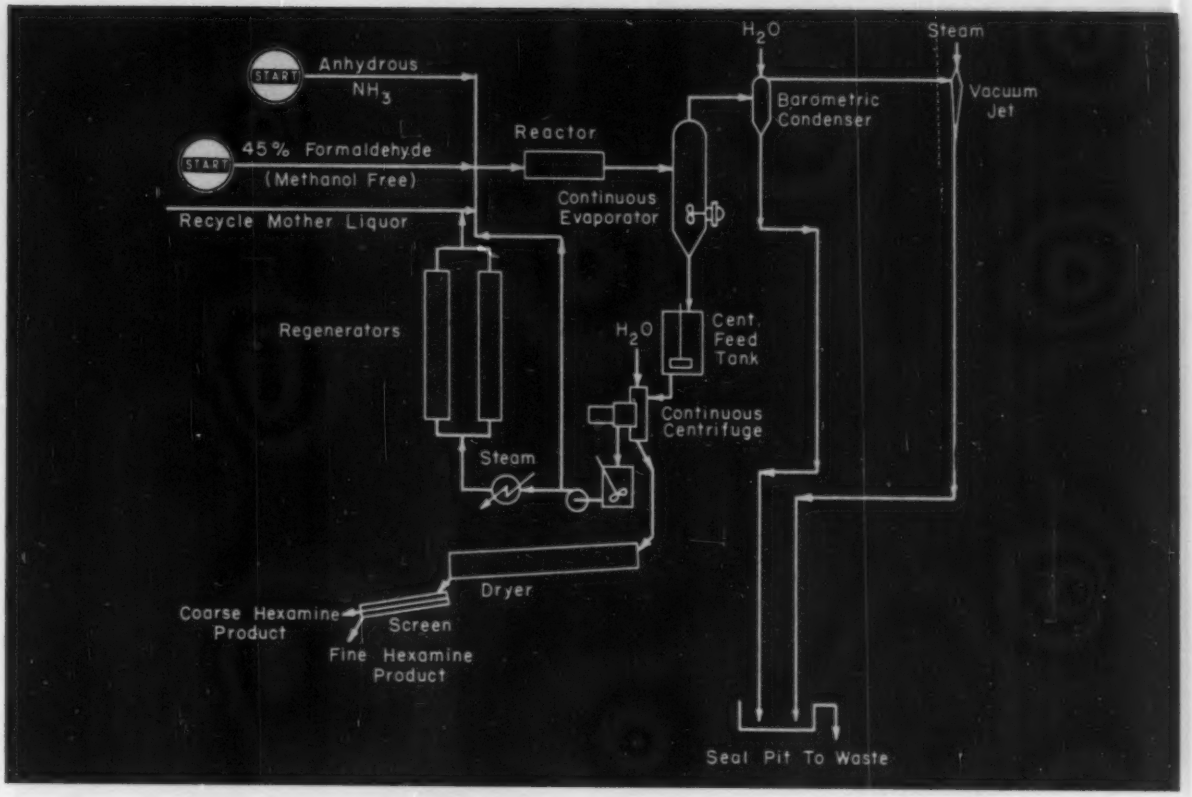


Operating Conditions: The hydroxylation is run near 50° C, and the maximum temperature in the reaction mixture fractionator is limited to 150° C. The methanolysis reaction operates at 105° C with 2 percent of 66° Be sulfuric acid as catalyst.

Yield: The yield of glycerol is 94 percent based on allyl chloride.

Commercial Installations: This process not yet in commercial operation.

Reference: Albert E. Corey and J. N. Crosby (to Allied Chemical and Dye Corp.) U.S. 2,739,173 (Mar. 20, 1956).



Hexamethylene Tetramine—THE LEONARD PROCESS COMPANY

Application: A continuous process for the manufacture of hexamethylene tetramine, $C_6H_{12}N_4$.

Charge: Technical grade anhydrous ammonia and 45 percent methanol free formaldehyde.

Product: Coarse or fine hexamethylene tetramine crystals.

Description: Technical grade anhydrous ammonia, 45 percent methanol free formaldehyde, and recycle mother liquor are fed continuously at controlled rates to a high velocity reactor. Since the reaction is exothermic, the flow of recycle liquor is kept high enough to keep the reaction temperature below the decomposition temperature of the hexamine, but by discharging the reactor effluent directly into the vacuum evaporator, the heat of reaction supplies the bulk of the heat needed to drive off the water of reaction. When sufficient water is removed, the hexamine crystallizes from solution so that the continuous evaporator serves both as evaporator and crystallizer. Slurry from the evaporator is fed to a continuous centrifuge (washing type) which separates the hexamine crystals and discharges them to a rotary dryer, and then to a vibrating screen for separation into fine and coarse crystalline product. The mother liquor and wash water from the centrifuge are pumped back through the continuous reactor. A small side stream of this mother liquor is continuously pumped through a regenerator system to remove byproduct impurities and prevent building up such impurities in the system.

The entire operation is continuous and is controlled by instruments so that one operator per shift controls the plant except for product packaging which requires one packer per day.

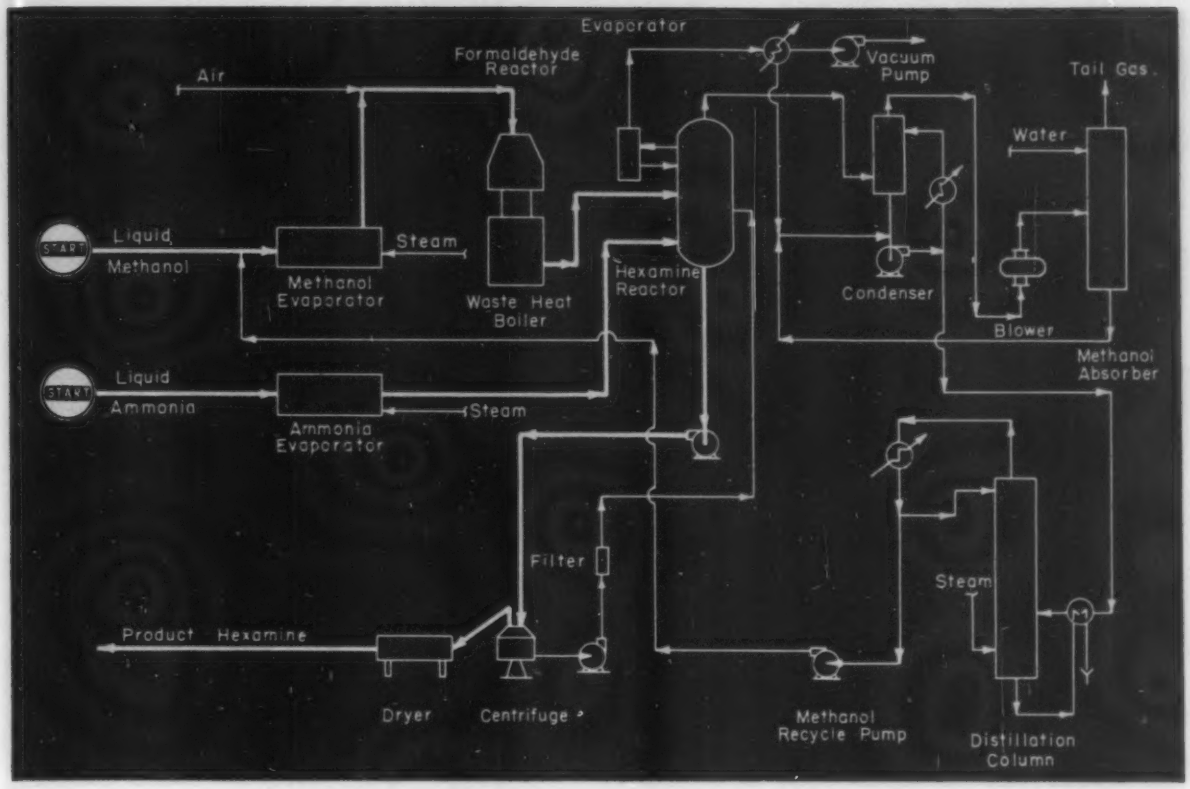
High yields and minimum byproduct formation are accomplished by careful control of reactor temperature, pH, and concentration.

All process equipment in contact with the hexamine solution or product is fabricated of stainless steel to keep the product pure and free of color.

Yields: Over-all yield of both ammonia and formaldehyde is above 96 percent.

Commercial Installations: The continuous process has been developed from operating data and experience with the various Ordnance Works that produced Hexamine during the last war for the manufacture of RDX explosive. The Ordnance Works utilized a batch operation and made no attempt to utilize heat of reaction. Several continuous plants are now in operation in Europe.

Reference: PETROLEUM REFINER, Sept.,'58,p.351.



Hexamine (Meissner Process)—GIRDLER CONSTRUCTION DIV., CHEMETRON CORP.

Application: A process for the manufacture of hexamethylene tetramine (hexamine).

Charge: Anhydrous ammonia and methanol.

Product: High purity, white crystalline hexamine.

Description: Hexamine is the reaction product of formaldehyde and ammonia. In most plants formaldehyde is first produced by catalytic oxidation of methanol. The formaldehyde is then absorbed in water to produce a solution which is freed from unreacted methanol by rectification. The aqueous formaldehyde solution is reacted with ammonia in the hexamine plant, the reaction mixture being subject to considerable cooling. The dilute hexamine solution produced is then vacuum evaporated to form crystalline hexamine. This is followed by centrifuging, washing, and drying operations.

In the process developed by the German firm of J. Meissner, formaldehyde and hexamine production are carried out in an integrated plant where the following three reactions take place:

(1) $CH_3OH + \frac{1}{2} O_2 \rightarrow CH_2O + H_2O$

(2) $CH_3OH \rightarrow CH_2O + H_2$

(3) $6\ CH_2O + 4\ NH_3 \rightarrow (CH_2)_6N_4 + 6\ H_2O$

Thus, the formaldehyde-containing gas obtained by oxidation of methanol (Reactions 1 and 2) is converted directly into hexamine by reaction with ammonia (Reaction 3) without intermediate condensation and absorption in water. The reaction heat obtained in this operation is used completely for evaporating the hexamine solution. Thus, the absorption of the formaldehyde, the reaction to form hexamine, and the evaporation are carried out in one unit which supplies crystalline hexamine without consumption of steam for heating.

The reactor is operated under vacuum which is maintained by a vacuum pump connected to a small separate evaporator used to adjust the water content of the system.

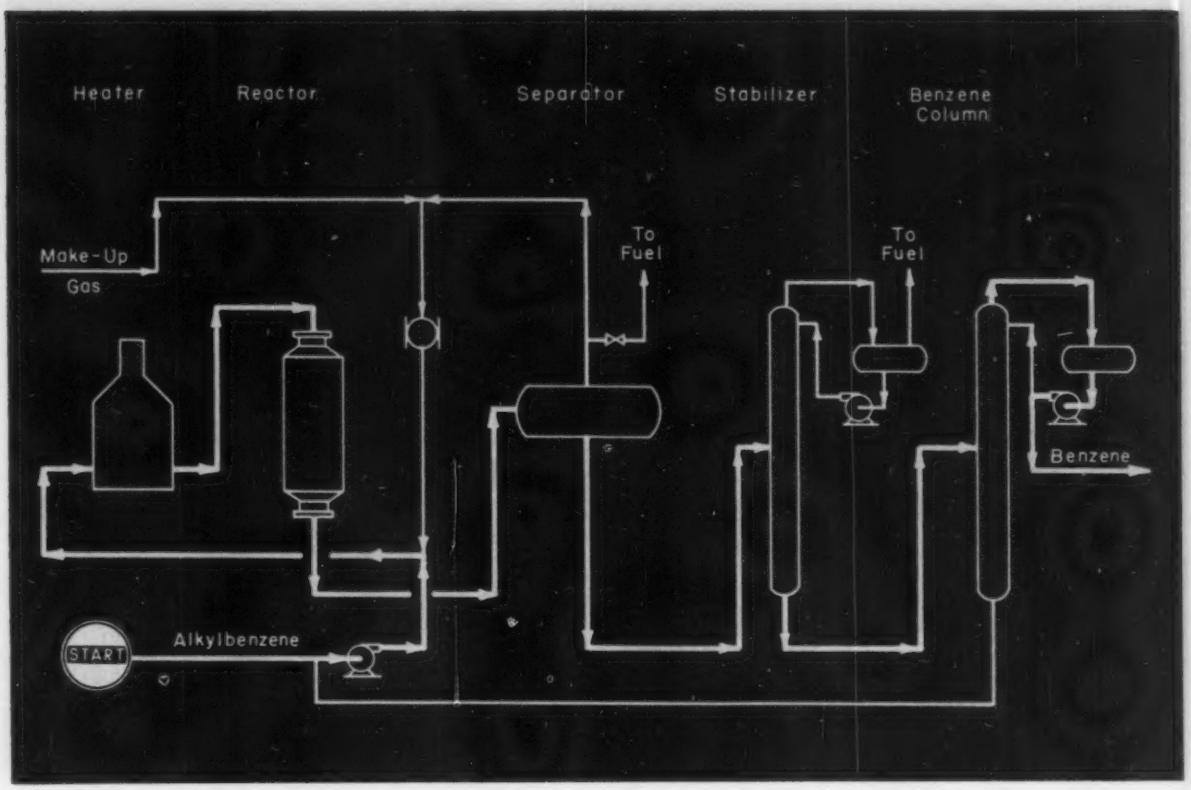
When using a silver catalyst for producing formaldehyde an appreciable amount of unreacted methanol is present in the tail gases. In most cases it is economical to recover this methanol by a two-stage condensing and absorbing system as shown. The methanol is then recovered by distillation and may be reused in the production of formaldehyde.

The hexamine slurry in the reactor is pumped to a centrifuge and the mother liquor is filtered and returned to the reactor. Thus a constant concentration of hexamine is maintained in the solution and uniformly large crystals may be formed. The solid hexamine from the centrifuge is dried in a rotary dryer.

Yield: Meissner will guarantee a hexamine yield of 97 percent from both ammonia and formaldehyde and an 89 percent yield of formaldehyde from methanol when methanol recovery is included. Thus 100 pounds of hexamine can be produced from 50 pounds of ammonia and 160 pounds of methanol.

Commercial Installation: The German engineering firm of J. Meissner has installed two plants in France with daily capacities of 4 and 8 metric tons and one in Egypt with a capacity of 1000 kilograms per day. Other units to be installed in Europe are being engineered currently. Girdler Construction Division is Meissner's agent in North America.

References: *Chemical Engineering,* Sept.'57,p56; *Industrial and Engineering Chemistry,* Vol.46,April'54p724.



Hydeal— UNIVERSAL OIL PRODUCTS COMPANY

Application: A process for the catalytic dealkylation of toluene or C_8 aromatics to produce benzene. Other applications include the dealkylation of alkylnaphthalenes to naphthalene and cresols to phenol.

Charge: Toluene and/or C_8 aromatics, either pure or in a mixture with other hydrocarbons, and a hydrogen-containing gas.

Products: Nitration-grade benzene, naphthalene and phenol.

Process Description: Fresh and recirculating hydrogen are combined with fresh and recycle alkylbenzenes. The hydrogen may be obtained from off-gas from a reforming unit to yield sulfur-free products.

The combined feed is brought to reaction temperature and charged to the reactor. Alkylaromatics are converted to benzene in accordance with the equations:

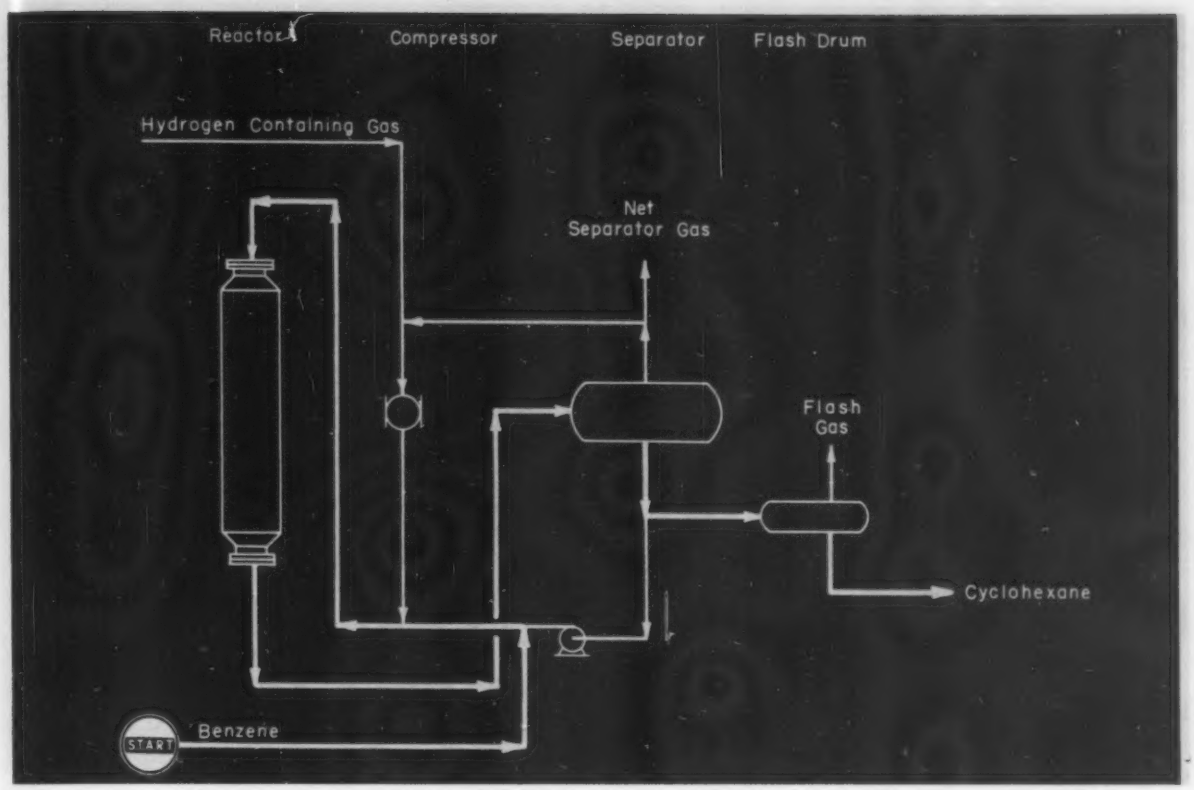
$$C_6H_5CH_3 + H_2 \rightarrow C_6H_6 + CH_4$$

$$C_6H_4(CH_3)_2 + 2H_2 \rightarrow C_6H_6 + 2CH_4$$

Reactor effluent is cooled and charged to the separator, from which hydrogen is taken and recycled to the reactor. The liquid from the separator passes to the stabilizer for stripping of hydrocarbons boiling lower than benzene. Nitration-grade benzene is taken overhead from the final column, and the bottoms are recycled to the reactor for dealkylation.

Yields: Yields of benzene from the hydrodealkylation of toluene are 90-95 percent of theoretical; yields of benzene from xylene are approximately 85-90 percent.

Licensing: This process was jointly developed by Ashland Oil & Refining Company and Universal. It is licensed by Universal under the patent rights of both companies.



Hydrar— UNIVERSAL OIL PRODUCTS COMPANY

Application: A process for the catalytic hydrogenation of benzene to produce high-purity cyclohexane. The UOP Hydrar process also is capable of converting toluene and higher aromatics to their respective cycloparaffins.

Charge: Benzene and a hydrogen-containing gas.

Product: The purity of the cyclohexane product is a function of the purity of the benzene feed. If the benzene is 99.8+ percent pure, as is the case when it is produced by a Udex unit, the cyclohexane will have a freeze point of 6.0° C, indicative of less than 0.2 wt-percent impurities.

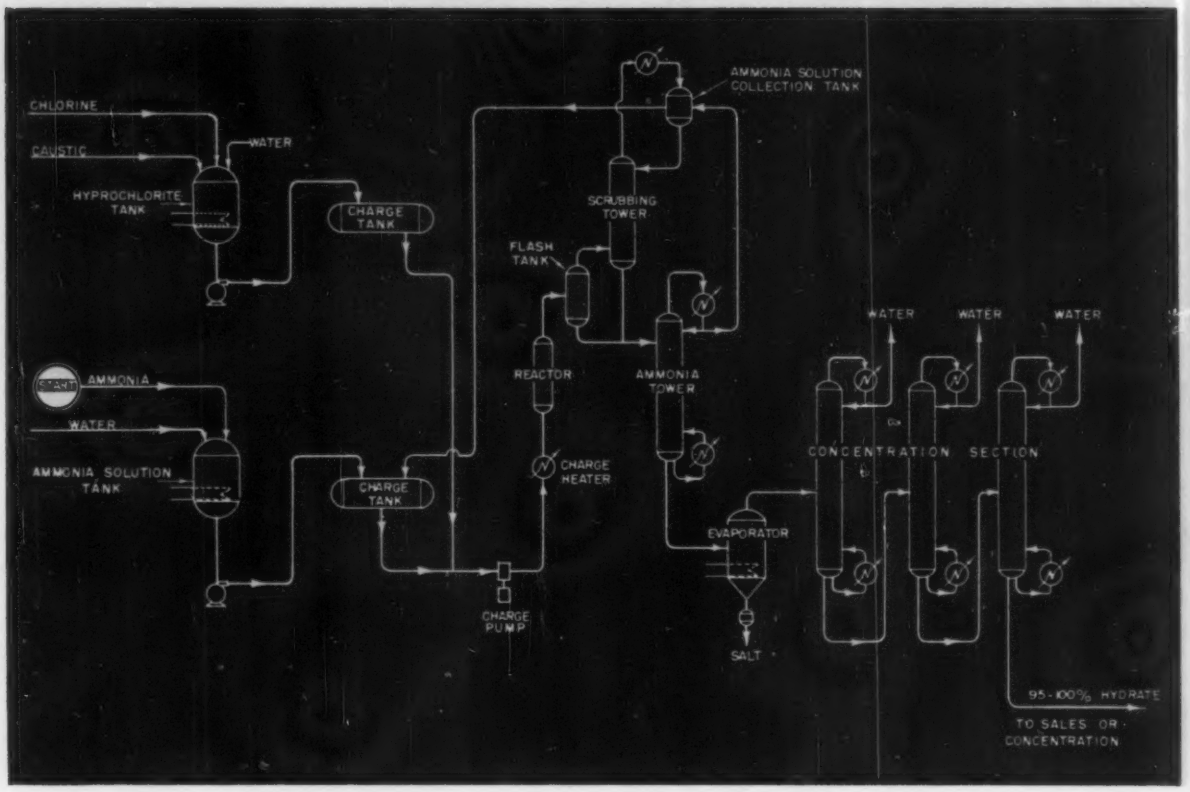
Process Description: Benzene feed, recycle cyclohexane and fresh and recycle hydrogen are brought to reaction temperature and charged to the reactor. The conversion of benzene to cyclohexane is stoichiometric. The reactor effluent, after exchanging heat with the feed, is charged to the separator. Gas from the separator is recycled to the reactor, a small net gas stream being removed.

A portion of the cyclohexane from the separator is recycled to the reactor to assist in the control of the reaction temperature. Product cyclohexane is flashed and/or stabilized to remove light hydrocarbons.

Operating Conditions: Operating conditions are moderate, allowing the use of carbon steel throughout the plant.

Yield: Virtually stoichiometric yields of cyclohexane from benzene are obtained.

Commercial Installations: One Hydrar unit is presently under construction and another has been licensed for construction in the near future.



Hydrazine

Application: A process for manufacturing hydrazine.
Charge: Dilute caustic soda (8 percent), chlorine, ammonia.
Product: Anhydrous hydrazine, 95+ percent, N_2H_4; hydrazine hydrate ($N_2H_4 \cdot H_2O$), 95-100 percent purity.
Description: Chlorine and dilute caustic are mixed to produce an aqueous sodium hypochlorite (NaOCl) solution with a strength of about 70 gm/liter available chlorine. Anhydrous ammonia is dissolved in purified water to form a 28 wt-percent solution.

These ammonia and hypochlorite solutions are combined in a molar ratio considerably greater than the 2:1 stoichiometric requirement. Ratios as high as 20-50 NH_3:NaOCl have been used. The mixture is pumped to a pressure of 30 atmospheres, preheated to 320° F, and passed quickly through a tubular reactor.

The successive reactions which occur are:

$$NaOCl + NH_3 \rightarrow NH_2Cl + NaOH$$
$$NH_2Cl + NH_3 \rightarrow H_2N \cdot NH_2 + HCl$$

The reactions are quite rapid under the elevated-temperature conditions, the residence time being a matter of a few seconds.

Conversion of hypochlorite is practically complete. Yields are in the range of 80-90 percent if precautions are taken to eliminate certain metallic ions, particularly copper ions, which catalyze side reactions to form ammonium chloride instead of hydrazine. It is necessary to use carefully-purified water in the mixing and adjustment of concentration of the reactant solutions, and at the same time to employ a purified gelatin inhibitor.

The effluent from the reactor contains about 1.5 percent hydrazine in an aqueous solution together with NaCl, NaOH, unconverted ammonia, and minor amounts of side reaction products. The liquid is flashed to a pressure slightly above atmospheric to liberate ammonia. Small amounts of flashed hydrazine are recovered in a scrubbing tower irrigated by ammonia solution. The liquid from the flash chamber is combined with the bottoms stream from the scrubbing tower and fed to a fractionating column. This fractionator removes residual ammonia together with water to form a combined recycle ammonia solution of about 28 wt-percent strength.

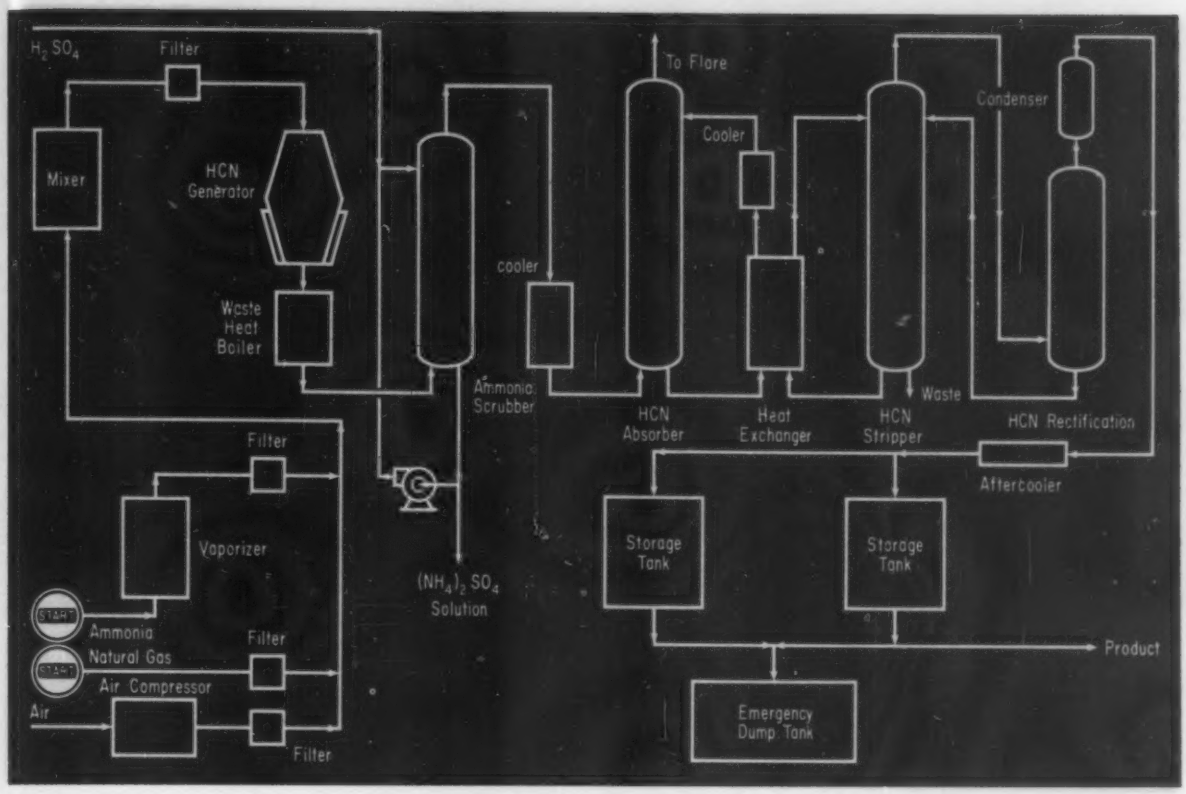
The bottoms from the ammonia tower contain the major impurities NaCl (5-6 percent) and NaOH (minor amount). The concentration of hydrazine hydrate ($N_2H_4 \cdot H_2O$) is about 3 percent. NaCl and NaOH are removed by salting-out in an evaporator. The vapors from the evaporator contain 6-8 percent hydrazine hydrate.

Further concentration of the hydrate is effected in a series of three distillation columns. The concentration becomes in turn 15 percent, 40-45 percent, and 95-100 percent hydrate. The intermediate strengths have certain commercial uses. The final tower, which produces concentrated hydrate bottoms material, is kept under a nitrogen blanket to minimize explosion dangers.

It is not possible to produce anhydrous hydrazine by simple distillation since water and hydrazine form an azeotrope at 71.5 wt-percent hydrazine. Concentration to anhydrous hydrazine (95+ percent) is effected by extractive distillation using ethylene glycol.

The product anhydrous hydrazine is a somewhat unstable liquid, an endothermic compound capable of decomposing with extreme violence. It is readily oxidizable. This combination of properties makes it of great importance as an explosive and as a fuel. Its most important present use is as a constituent in rocket and jet fuels; however, it has a great many other potential uses because of its reactive chemical nature.

Operating Conditions: Given in above text.
Yields: Over-all process yields of 70-75 percent are obtained, based on available chlorine raw material.
Commercial Installations: This process or a modification is used by: Olin Mathieson Chemical Corp., Lake Charles, La.; Fairmount Chemical Company, Newark, N. J.
Reference: Petroleum Refiner, Dec.'54,pp.166-167.



Hydrogen Cyanide (Andrussow Process)— GIRDLER CONSTRUCTION DIV., CHEMETRON CORPORATION

Application: A process applied to the manufacture of hydrogen cyanide. The reactor gas may also be used to produce alkali cyanides by absorbing hydrogen cyanide in caustic.

Charge: Natural gas and anhydrous ammonia are the charge.

Product: The product is 98.5 percent liquid hydrogen cyanide and 1.5 percent water.

Description: Hydrogen cyanide is produced by the reaction of ammonia, natural gas and air over a platinum catalyst and may be represented as follows:

$$NH_3 + CH_4 + 1.5\,O_2 \rightarrow HCN + 3H_2O$$

Ammonia and natural gas, under at least 5 to 10 psig pressure, are filtered and mixed prior to entering the converter vessel. The converter operates at 1,800° F. and pressures slightly above atmospheric. The approximate composition of the effluent gas is given below:

Composition of Gas Produced in Generator	Mole-Percent
Hydrogen cyanide	5.9
Ammonia	1.6
Carbon dioxide	0.2
Carbon monoxide	4.4
Methane	0.5
Hydrogen	7.5
Oxygen	0.1
Nitrogen	56.7
Water vapor	23.1
	100.0

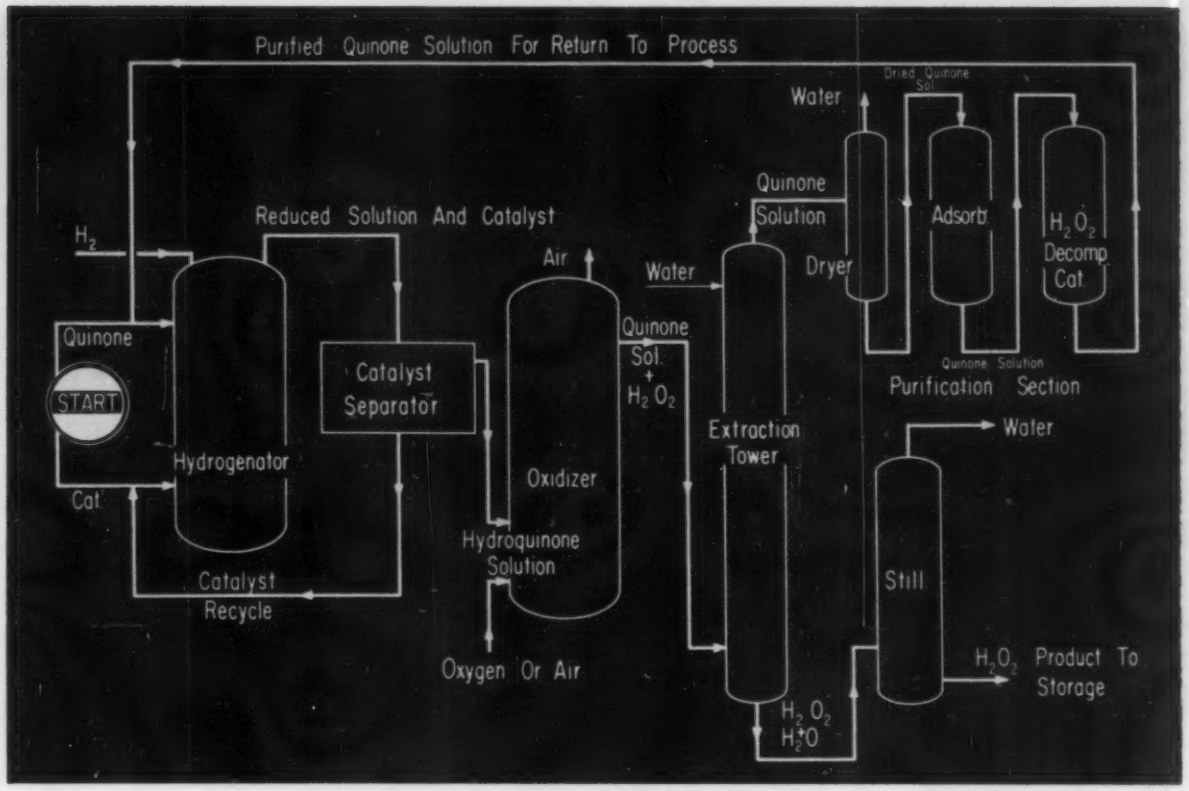
The effluent gases are cooled immediately in a waste heat boiler which produces 150 psig steam used in the process. The boiler is specially designed to avoid decomposition of the hydrogen cyanide.

Following the waste heat boiler the gases are washed with a dilute sulfuric acid-ammonium sulfate solution to remove unreacted ammonia from the reactor gases, and thus avoid formation of hydrogen cyanide polymers in the absorption and recovery system. The ammonium sulfate thus produced may be concentrated to produce crystalline ammonium sulfate or added to fertilizer solutions.

Following the ammonia scrubber, the gases are cooled and passed through a column where hydrogen cyanide is absorbed in water. The residual gases are flared and discharged to the atmosphere. The hydrogen cyanide is stripped from the water solution, rectified and liquefied. Suitable vapor and liquid phase inhibitors are used to avoid polymerization and stabilize the final product.

Yields: 63 to 70 percent of the ammonia is converted to HCN depending on operating conditions. Approximately half of the remaining ammonia is recoverable as byproduct ammonium sulfate.

Commercial Installations: A commercial operation having a capacity of approximately 20 million pounds per year has been in operation for a number of years.



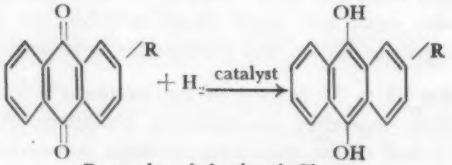
Hydrogen Peroxide— BECCO CHEMICAL DIV., FOOD MACHINERY & CHEMICAL CORP.

Application: A non-electrolytic process for manufacturing hydrogen peroxide.
Charge: An alkylated anthraquinone, quinone and hydroquinone solvents, catalyst, hydrogen, air or oxygen, water.
Product: Aqueous hydrogen peroxide of 15-35 percent concentration by weight.
Description: The process consists of reducing anthraquinone to hydroquinone, oxidation back to quinone with hydrogen peroxide production, extraction of hydrogen peroxide, and purification of process solution for recycle.

The alkylated anthraquinone, usually 2-ethyl or 2-tertiary butyl anthraquinone, is obtained from Friedel-Crafts reaction of phthalic anhydride or ethyl (or tertiary butyl) benzene.

The working solution (anthraquinone in solvent) is fed to the hydrogenator and reduced to the hydroquinone stage with hydrogen and catalyst. Solvents may be—aromatic hydrocarbons, alcohols, ketones, esters, etc.—which maintain the quinone and hydroquinone in solution.

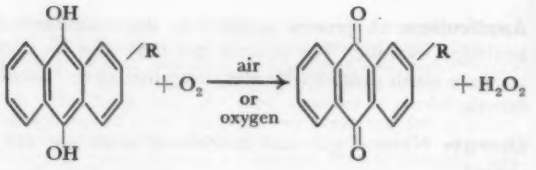
Hydrogenation is at room temperature to 40 C or more and hydrogen pressure of 1-3 atmospheres. Catalysts may be Raney nickel, nickel, palladium or platinum. Hydrogenation is less than theoretical to avoid hydroquinone precipitation and the formation of nuclear hydrogenated products. The main hydrogenation reaction is as follows:



R may be ethyl, t-butyl, Cl, etc.

Catalyst is removed from the hydrogenated solution by filtration or centrifugation and recycled. Catalysts used also decompose hydrogen peroxide and reduce yields in the oxidation step.

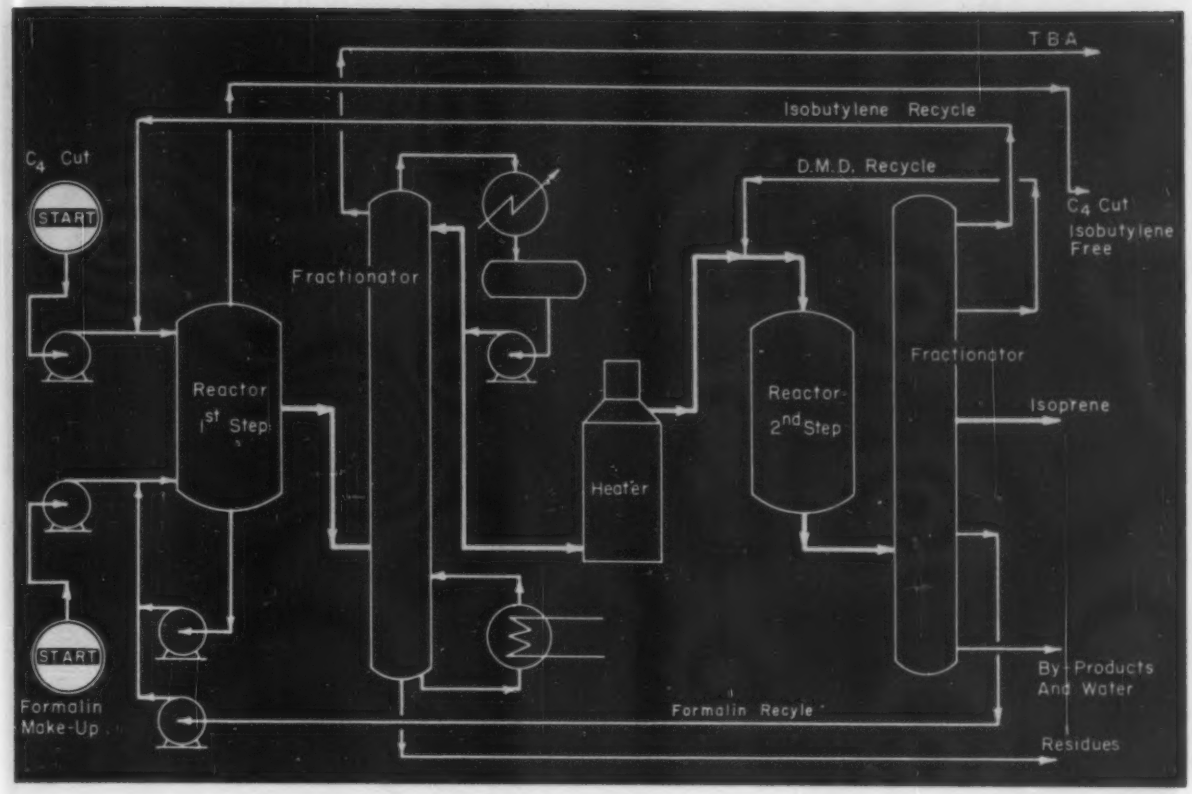
The hydroquinone solution then passes through a series of air or oxygen oxidizers. The hydroquinone is reconverted to quinone and hydrogen peroxide formed, as shown below:



The oxidized solution (½-1 percent hydrogen peroxide) is extracted, the hydrogen peroxide-rich organic solution rising countercurrent to the top entering water. The solvents used must yield operable density gradients and partition coefficients for hydrogen peroxide between aqueous and organic phases. Density gradients are 0.05-0.1 g/cm³. The extractors operate at 25-40 C. and yield 15-35 weight percent hydrogen peroxide. This solution goes to storage or to vacuum stills for concentration to any desired strength.

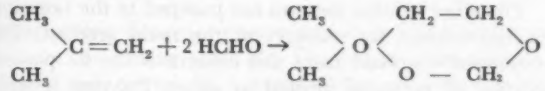
The organic phase, leaving the final extractor, is separated from entrained water and partially dried. Traces of hydrogen peroxide, if harmful to the catalyst, are removed by catalytic treatment before the work solution is recycled. A typical cycle requires 2-4 hours. A plant producing 100 lbs./hour of hydrogen peroxide (100% basis) may require 20,000-50,000 lbs. of work solution.

Operating Conditions: The principal operating conditions given above are influenced by the solvent, catalyst, etc.
Yields: The yield of hydrogen peroxide has been reported as 90 percent of the theoretical, based on hydrogen consumption.
Commercial Installations: This process, or a variation thereof, is reputedly used in plants operated or being built by the following chemical companies in the U. S.: Becco Chemical Division, Food Machinery and Chemical Corp., Buffalo, N. Y.; Columbia-Southern Chemical Corp., Barberton, Ohio; E. I. duPont de Nemours & Company, Memphis, Tenn.; and Solvay Process Division, Allied Chemical & Dye Corp., Syracuse, N. Y.
References: Kirk-Othmer "Hydrogen Peroxide," p 418, First Supplement (1957), Encyclo. Chem. Technology, Interscience Encyclo. Co., Inc. New York. *Chemical Week*, p75,No.5(1955). The *Industrial Chemist*, Jan.'59.

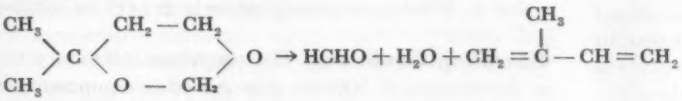


Isoprene—INSTITUT FRANCAIS DU PETROLE

Application: A process for the manufacture of isoprene.
Charge: Isobutylene in a C_4 cut and formaldehyde.
Product: Isoprene monomer of 99 percent minimum purity.
Description: The process involves two stages; the first consists in isobutylene-formaldehyde condensation according to Prins reaction, to give essentially dimethyl 4, 4 dioxane 1-3 (DMD)—



The second consists in elimination of water and formaldehyde to obtain isoprene—



Formaldehyde thus recovered is recycled to the first stage. The main feature of the process is that the carbon chain of isobutylene is increased by one carbon atom, and that this lengthening leads exclusively to the isoprene chain.

Practically the C_4 cut is brought in contact with a formaldehyde solution containing the catalyst. The reactor allows various exhaustion rates of isobutylene according to the various compositions of the C_4 cut. The reactor product is separated into DMD and a few TBA's by distillation. In the second stage, DMD is preheated and sent to the second reactor which contains an appropriate solid catalyst. The effluent from the second reactor is separated with unreacted DMD being recycled. Some isobutylene produced by a secondary reaction is recycled to the first stage.

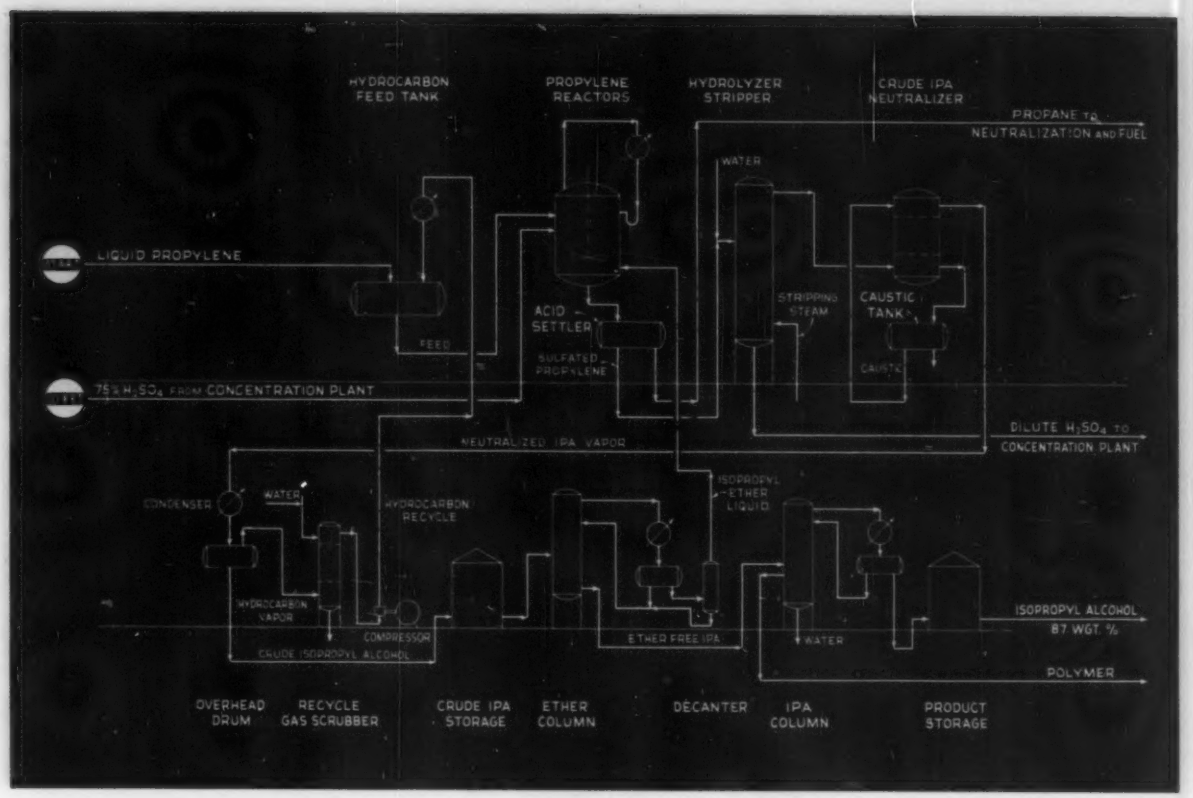
The crude recovered product is isoprene of very high purity practically free from piperylene and can be used as such for orientated polymerizations.

Operating Conditions: The condensation in the first stage is complete for temperatures of 250° F or lower. When using a C_4 cut containing other olefins, the catalyst is selective and only isobutylene is attacked. Optimum consumption of isobutylene in the mixed charge stream is essential to minimize formation of undesirable dioxanes and losses. For example, it is higher than 80 percent for cuts containing 25 percent of isobutylene and 25 percent of 1 and 2 butylenes.

The unit capacity of the first stage is 43.5 tons per year per cubic foot of reactor. The decomposition of DMD is endothermic (—120 Btu/mole), but when using proper catalyst it occurs under mild conditions. The unit capacity of the second stage is 15.6 tons per year per cubic foot of reactor.

Yields: 238 moles formaldehyde and 136 moles isobutylene yields 100 moles isoprene, 10.3 moles TBA, 19.2 moles by-products, 1 mole carbon. In addition 106 moles formaldehyde and 15.9 moles isobutylene are returned and recycled. It is estimated that a 40,000 metric ton-per-year plant could be built for $13 million including formaldehyde unit starting from methanol.

Reference: Fifth World Petroleum Congress, Section IV.



Isopropyl Alcohol— STONE & WEBSTER ENGINEERING CORPORATION

Application: A process for manufacturing isopropyl alcohol.

Charge: Liquid propylene. A feed of 65 percent purity or better is desirable to achieve a high alcohol yield, although much lower concentrations of propylene can be handled satisfactorily.

Product: The product is a solution of 87 weight percent isopropyl alcohol. This product can be concentrated to 99 weight percent alcohol by adding one more fractionating step.

Description: The liquid propylene feed stock, combined with recycled hydrocarbons, is first absorbed in 75 percent sulfuric acid in a series of agitated reactors to form a solution of diisopropyl sulfate and isopropyl acid sulfate. The sulfated hydrocarbon solution is converted to an acid solution of isopropyl alcohol, ether and polymer by hydrolysis reactions which take place in the hydrolyzer-stripper in the presence of dilution water. These reaction products are stream stripped from the acid in the same column and leave as overhead vapors. The vapors are neutralized by contact with caustic solution and then condensed.

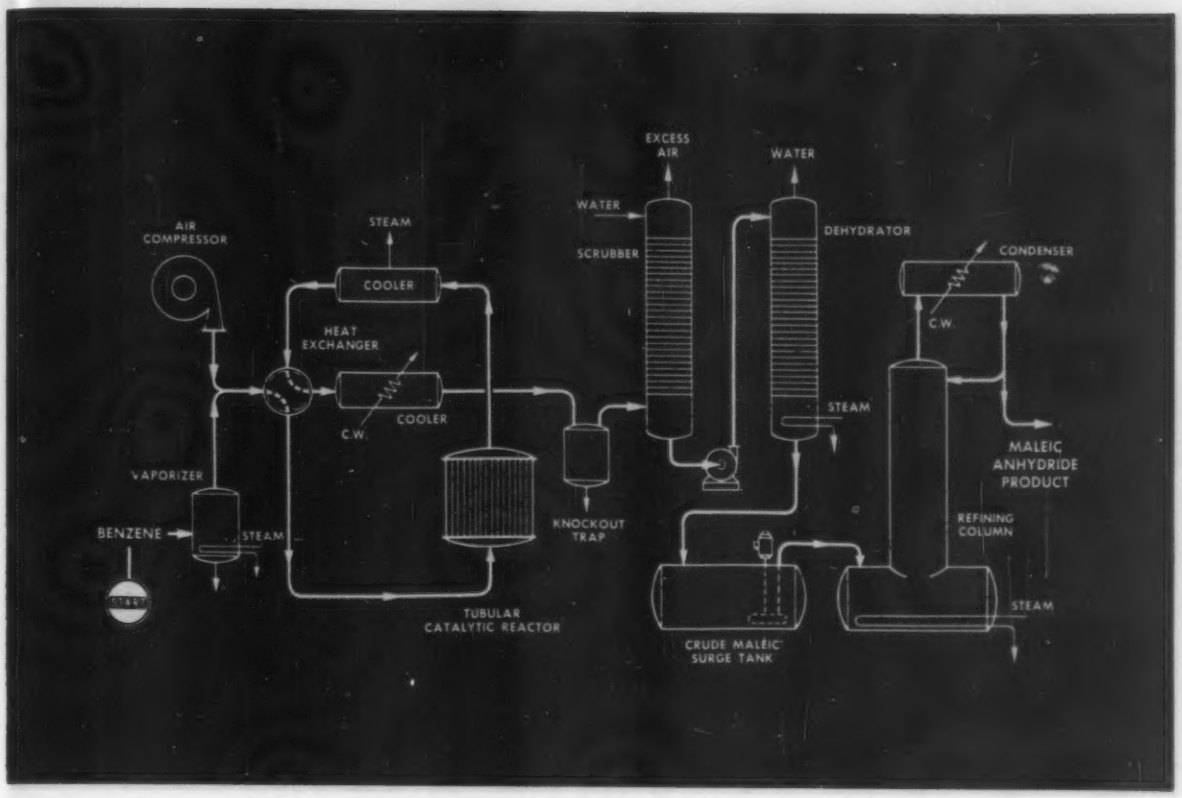
The crude isopropyl alcohol is charged to the ether column. The bulk of overhead vapors from this column is condensed and refluxed to the column. A portion of the liquid is diverted from the main reflux stream and sent to a decanter for separation. In the decanter the two liquid layers are separated; the upper layer is very rich in ether, and the lower layer contains mainly water and small amounts of ether and alcohol. The lower water-rich layer is refluxed back to the tower continuously along with the main reflux stream going to the column. The ether-rich layer is pumped back into the reaction system.

The ether column bottoms are pumped to the isopropyl alcohol column for recovery of the main product. The condensed overhead from this column is the 87 percent solution of isopropyl alcohol in water. Polymer is withdrawn as a side stream from the column and pumped to storage. From the base of the isopropyl alcohol column, water is withdrawn containing only traces of alcohol.

Operating Conditions: The propylene sulfation occurs in the reactors at 300-400 psig. All other equipment, except for the propylene feed tank, operates at near atmospheric pressures. No mechanical refrigeration is required.

Yields: Ninety-three to 95 percent of propylene charge is converted to isopropyl alcohol, depending on propylene content of charge stock.

Commercial Installations: This process is based on development work carried out by the Distillers Company, Ltd., with recent improvements by Stone & Webster. Commercial plants using this process are operating in the United Kingdom and Japan.



Maleic Anhydride— SCIENTIFIC DESIGN COMPANY, INCORPORATED

Application: A process for the manufacture of maleic anhydride.

Charge: Benzene, nitration grade.

Product: Maleic anhydride, pellets.

Description: Benzene is vaporized in kettles and fed to a vessel for mixing with air. The mixed gases are preheated and passed to a multitubular, cooled catalytic reactor.

The reactor effluent gases pass through three coolers in sequence. The first cooler generates steam. The second is a recuperative exchanger which serves to preheat feed gas. The third cooler uses cooling water. Tarry condensates are removed by a knockout trap. The reactor effluent gases then pass to a water scrubber where maleic anhydride is absorbed. The maleic acid solution is pumped to a dehydrator which regenerates maleic anhydride. Only a minimum of maleic is transformed to isomeric fumaric acid in the dehydration step, by careful control of conditions. The crude maleic anhydride is purified in a refining column. The product cut is pelletized and bagged in conventional machines.

Tempered cooling water is used to prevent plugging of the reactor aftercooler by solid maleic anhydride. A startup heater (not shown on this schematic flow diagram) serves to bring the feed airstream up to reaction temperature. This preheater burns natural gas or other cheap fuel.

Several oxidations take place simultaneously in the reactor; the two most important reactions are represented as follows:

(1) $C_6H_6 + 4\frac{1}{2}\,O_2 \rightarrow C_4H_2O_3 + 2\,H_2O + 2\,CO_2$

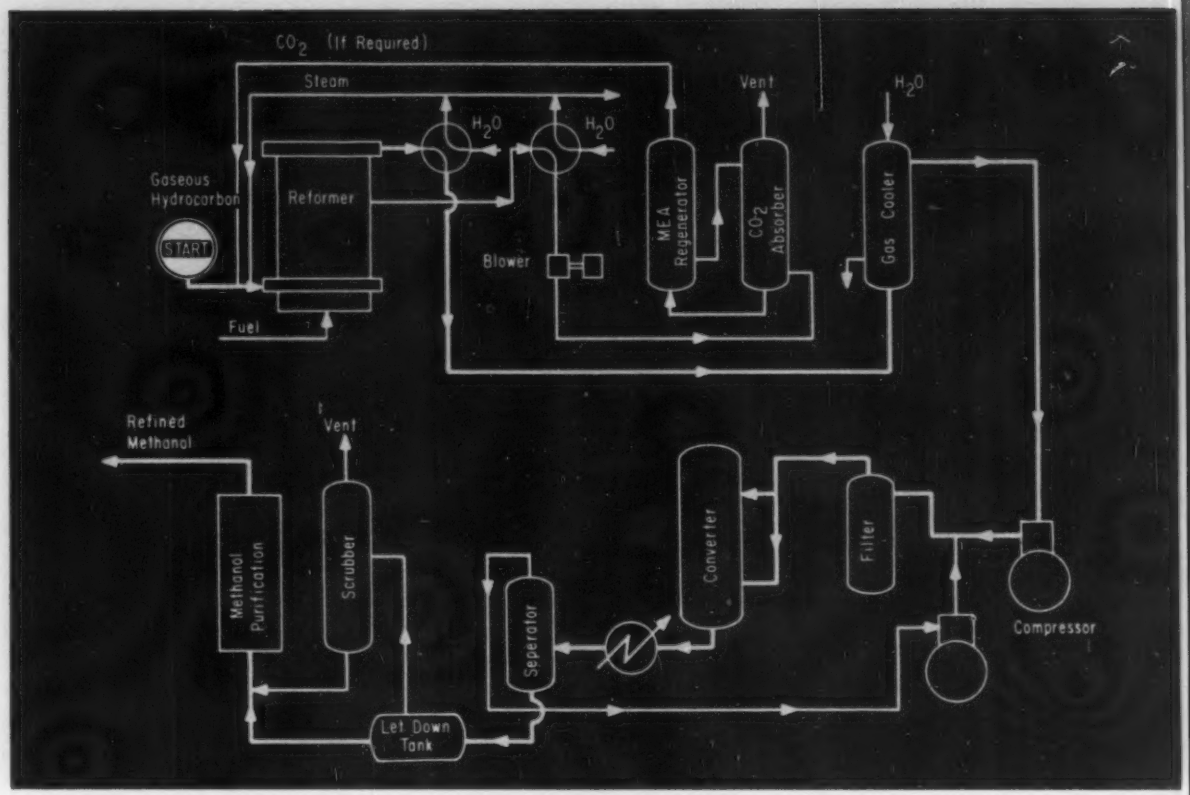
(2) $C_6H_6 + 7\frac{1}{2}\,O_2 \rightarrow 6\,CO_2 + 3\,H_2O$

Operating Conditions: The most important operating variables are the benzene concentration in the reactor inlet gases, the temperature in the reactor, and the contact time.

A careful analysis of all these parameters has permitted SD's maleic anhydride process to achieve hitherto unattained commercial yields.

Commercial Installations: Compagnie Francaise des Matieres Colorantes, Villers-St. Paul, France; American Cyanamid Company, Bridgeville, Pa.; Ftalital S.p.A., Scanzorosciate, Italy; Monsanto Chemicals Limited, Newport, Monmouthshire, England; Monsanto Chemical Company, St. Louis, Missouri. A reaction system using the Scientific Design Company catalyst has been in commercial operation at Reichhold Chemicals' Elizabeth, N. J., plant for several years.

Reference: *Chemical Engineering,* July'53,p238, *Petroleum Processing,* Nov.(1956),p82-89.



Methanol—CHEMICAL CONSTRUCTION CORPORATION

Application: This is a process for the manufacture of methanol.

Charge: The feed to the process may be any mixture of gaseous hydrocarbons below hexane consisting primarily of saturates, or acetyline off-gas, or a mixture of hydrocarbons and off-gas.

Description: Hydrocarbons are reformed to hydrogen, carbon monoxide and carbon dioxide by reaction with steam at about 30 psig.

Methanol requires slightly different reformer operating conditions than those for the production of ammonia synthesis gas. A somewhat lower reformer pressure is used and there is no secondary reforming step. No carbon monoxide shift converter is required for methanol production.

Some feed gases require that carbon dioxide be added to the gas stream before reforming. In this case the required quantity of carbon dioxide is recovered from the flue gas from the reforming furnace by scrubbing with MEA solution, if carbon dioxide is not available from another source.

The reformed gas is cooled in a waste heat boiler and then by direct contact with water. It is then compressed to 5200 psig at which pressure it is synthesized to methanol as illustrated.

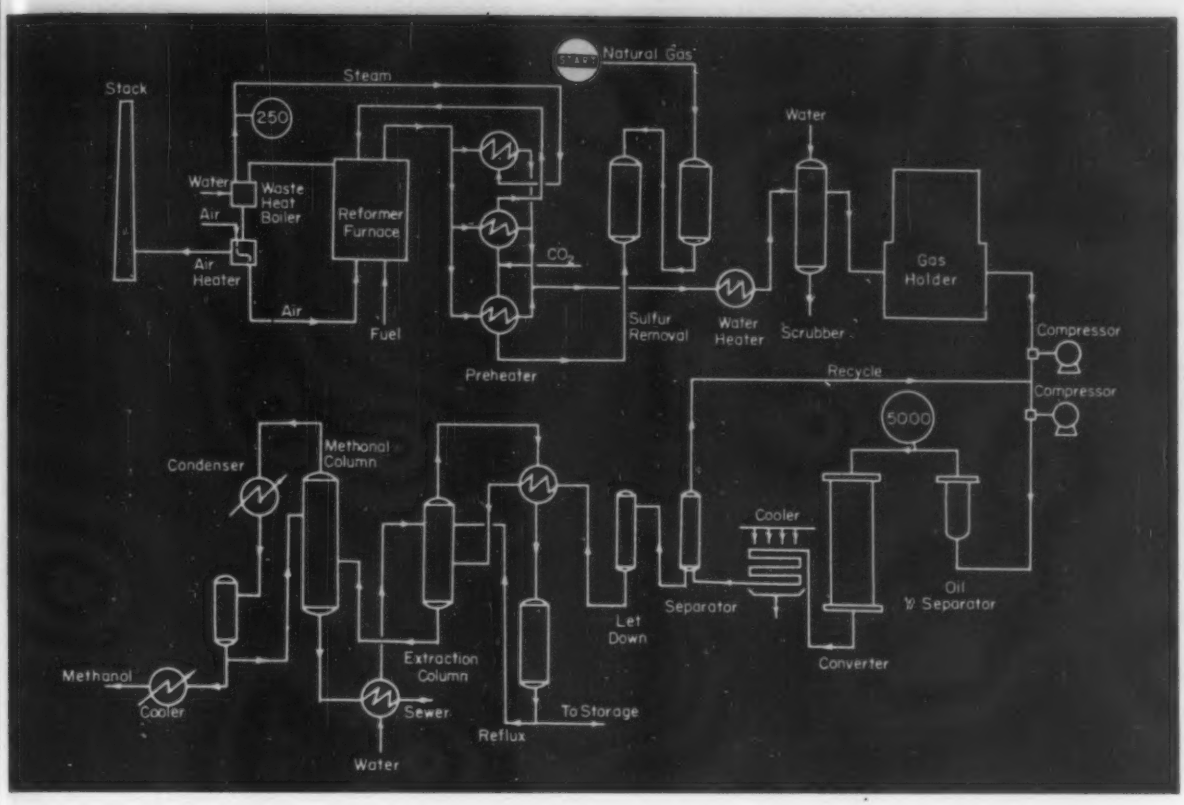
The Methanol is almost completely condensed in a water cooled exchanger and then passes into the separator. Gases dissolved in the raw product methanol at 5000 psig flash from the liquid when the pressure is reduced in the let-down tank. Methanol in the flashed gas is recovered and mixed with the raw product.

The raw product is then refined by distillation.

Products: The refined product methanol has a purity of 99.85 percent.

Operating Conditions: Important operating conditions are given in the preceding description.

Commercial Installations: There are several domestic and foreign installations in operation or under construction.



Methanol— COMMERCIAL SOLVENTS CORPORATION

Application: A process for the manufacture of methanol.

Charge: Natural gas.

Product: Methanol.

Description: The first step in the process is the removal of organic sulfur and hydrogen sulfide from the natural gas feed stock. This is accomplished in the sulfur removal vessels by contacting the gas with activated carbon.

The purified gas is pre-heated by exchange with reformer products, mixed with carbon dioxide and superheated steam and passed downward in the reformers. The reformers are heated with fuel gas and the flue gas is used to generate 250 psi steam and to heat the primary combustion air for the reformer heater burners. The reformer product stream is further cooled in the feed water heater and then water quenched before going to a gas holder.

The cooled reformed gas from the gas holder is compressed to 5000 psig by the primary compressors and the circulating compressors. This high pressure gas stream flows to oil traps for the removal of entrained oil before being introduced to the converters. The outlet from the oil trap vessel and filter is divided into three streams. The main stream goes to the converter top and a small bypass stream sent to the bottom of the converter for quench while a small stream is sent to the quench lines at the top of the reactor. The converter effluent is cooled in a spray cooler and flows to a separator. The unconverted gases from the separator are recycled to an intermediate stage of the primary compressors and the condensed product from the separator flows to the low-pressure let-down and separator drum. The liquid product from the let-down drum flows to crude methanol storage.

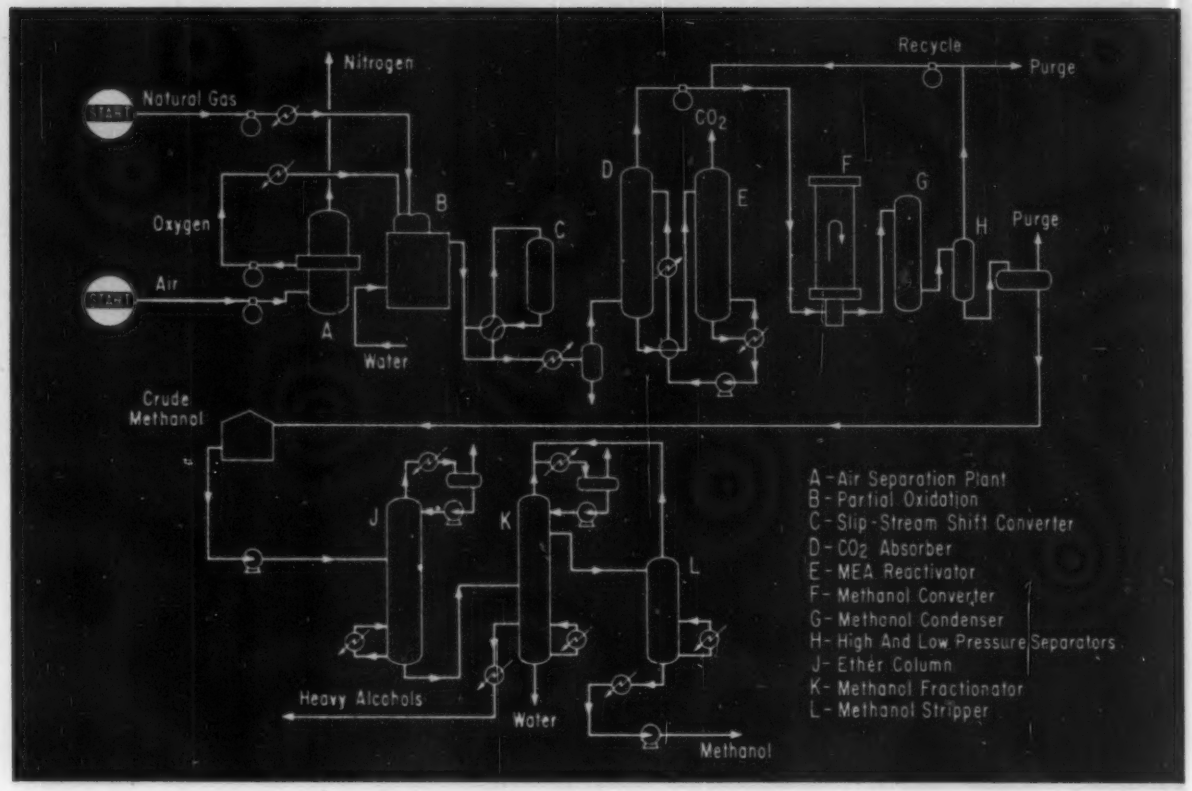
The impurities present in the crude methanol (isopropyl and isobutyl alcohol, traces of ethers, ketones and aldehydes) have boiling points near that of methanol itself and present a real problem in the purification of methanol. The extractive distillation method is used by Commercial Solvents Corporation.

The crude methanol is preheated in the extraction column condensers and fed to the extraction column. The heads from this column are partially used for reflux and the remainder cooled and sent to intermediate storage. Soft water, heated by exchange with the methanol column bottoms, is introduced as extract in the extraction column. The bottoms from the extraction column are fed to the methanol column where the overhead is finished methanol product. A portion of this overhead is used for reflux on the methanol column. The bottoms are sent to sewer. A bottom fraction is removed from the methanol column and goes to the tails column for the recovery of higher alcohols.

Operating Conditions: The converter operates at 5,000 psig and 400° C. with about 12 to 15 percent conversion of feed gas to methanol per pass.

Commercial Installation: Commercial Solvents Corporation, Sterlington, La.

Reference: *Chemical Engineering,* June '55.



Methanol— FOSTER WHEELER CORPORATION

Application: A process for the manufacture of methanol.

Charge: Hydrocarbon gas and/or oil, water and air.

Product: Methanol.

Description: The methanol synthesis process described in the flow diagram represents the combined development efforts of Casale and Foster Wheeler. It is based on the catalytic union at high pressure of hydrogen and carbon monoxide following the formula: $CO + 2H_2 \rightarrow CH_3OH$.

Filtered air, compressed to approximately 85 psig, enters the air separation plant where it is separated into oxygen and nitrogen. The nitrogen may be utilized in a separate ammonia synthesis plant; otherwise, it is vented to the atmosphere. Oxygen of 98 percent purity is compressed to approximately 425 psig and delivered to the synthesis gas generation section (Texaco partial oxidation).

Natural gas is compressed, preheated and joins the oxygen in the Texaco generator. The partial oxidation reaction produces a crude synthesis gas consisting principally of hydrogen and carbon monoxide. The bulk of this gas is cooled and flows to the purification section. A slip stream passes through a shift converter where catalytically, some of the carbon monoxide reacts with water vapor to form additional hydrogen so that the molal proportions of hydrogen and carbon monoxide in the total gas will be suitable for the methanol synthesis.

The effluent from the shift converter, is cooled and flows to the purification section where carbon dioxide is removed by scrubbing synthesis gas with a solution of monoethanolamine.

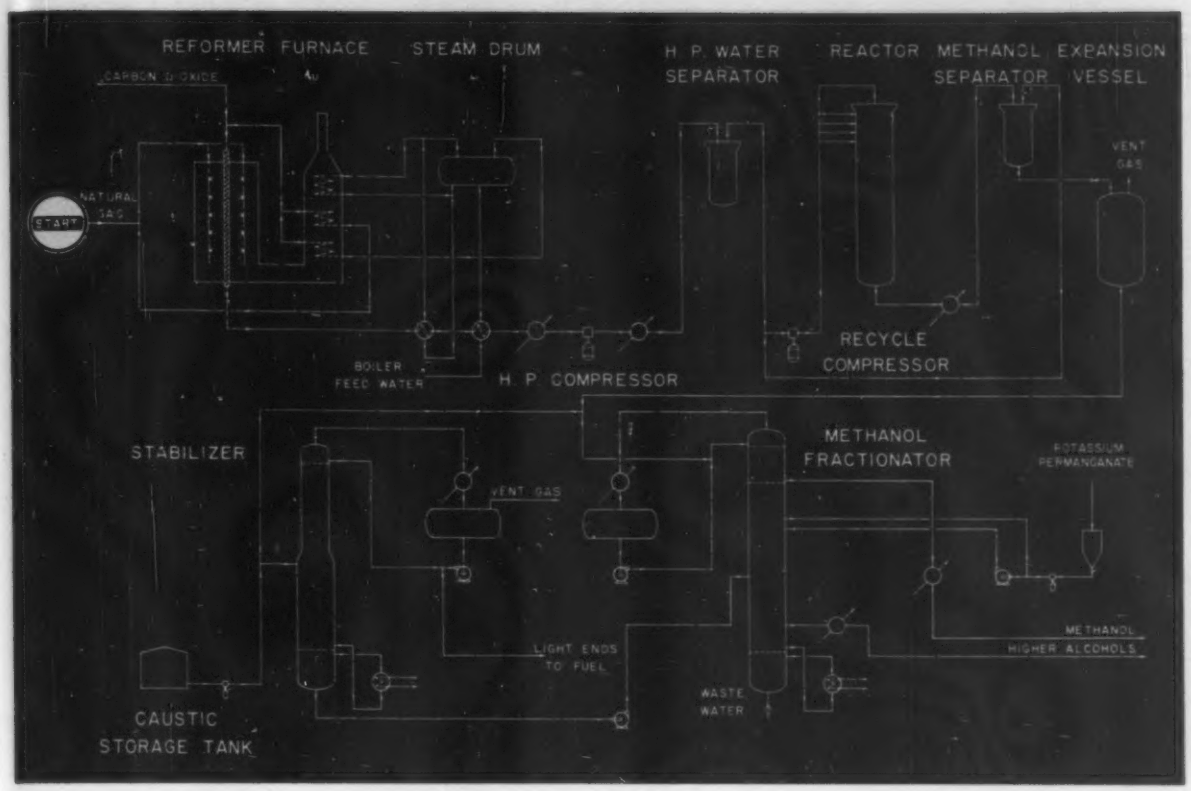
The purified gas, now mainly hydrogen and carbon monoxide, is compressed to approximately 6,500 psig and enters the Casale reactor in which the catalytic synthesis to methanol takes place. The reactor effluent is partially condensed and flows to a two-stage separating system in which unconverted hydrogen and carbon monoxide is separated, compressed and returned, as recycle, to the Casale reactor. The liquid from the low pressure separator is crude methanol which flows to storage.

Crude methanol is purified either by fractional or extractive distillation. In the former system, crude methanol is pumped to a fractionating column for the removal of light ends. These light ends (ether) are partially condensed and used as reflux to the column, and the uncondensed gases are vented to flare. The bottoms from this column flow to a methanol fractionating column where pure methanol is recovered as a side stream. A second side stream of higher alcohols, with some methanol and water is also withdrawn from the column and the water is rejected from the bottom.

The purified methanol stream next passes into a small stripper which removes the last traces of ether. The stripped product, pure methanol, is cooled and pumped into the product rundown tank.

Operating Conditions: Important operating conditions are described above.

Commercial Installations: 100 ton/day installed capacity.



Methanol (Uhde)—ARTHUR G. McKEE AND COMPANY

Application: A process for manufacturing synthetic methanol.

Charge: Natural gas, ethane, LPG, any light hydrocarbon.

Product: Pure anhydrous methanol.

Description: Methanol is produced by the reaction of carbon monoxide or carbon dioxide with hydrogen. The process is catalytic and carried out at elevated temperature and pressures. Any suitable source of H_2 and CO or CO_2 may be used to produce the synthesis gas. Under U.S. economic conditions the most favorable source is high-pressure reforming of natural gas with steam.

Steam-methane reforming produces a gas in which the ratio H_2/CO is higher than desirable for the methanol reaction. This ratio is theoretically 2.0, but a ratio of 2.25 is normal practice. To achieve the desired balance, carbon dioxide from any available outside source may be added in the H_2/CO_2 ratio of 3.25 to react with excess H_2.

In steam-methane reforming the natural gas at approximately 150° F is preheated to 850° F and mixed with steam likewise preheated to 950°-1000° F. Carbon dioxide required to achieve the desired $H_2/CO + CO_2$ ratio is added, and the mixture passes to a bank of catalyst tubes in the radiant section of a furnace. High temperatures favor the reforming reaction. Excess steam is used to insure complete utilization of the methane.

Leaving the catalyst tubes the mixture is quenched with water to bring its temperature below reaction temperature as quickly as possible. It then exchanges heat with boiler feed water and is cooled with water before going to the high pressure compressor. This compressor raises the pressure of the mixture to that of the reactor system, 4,600 psig.

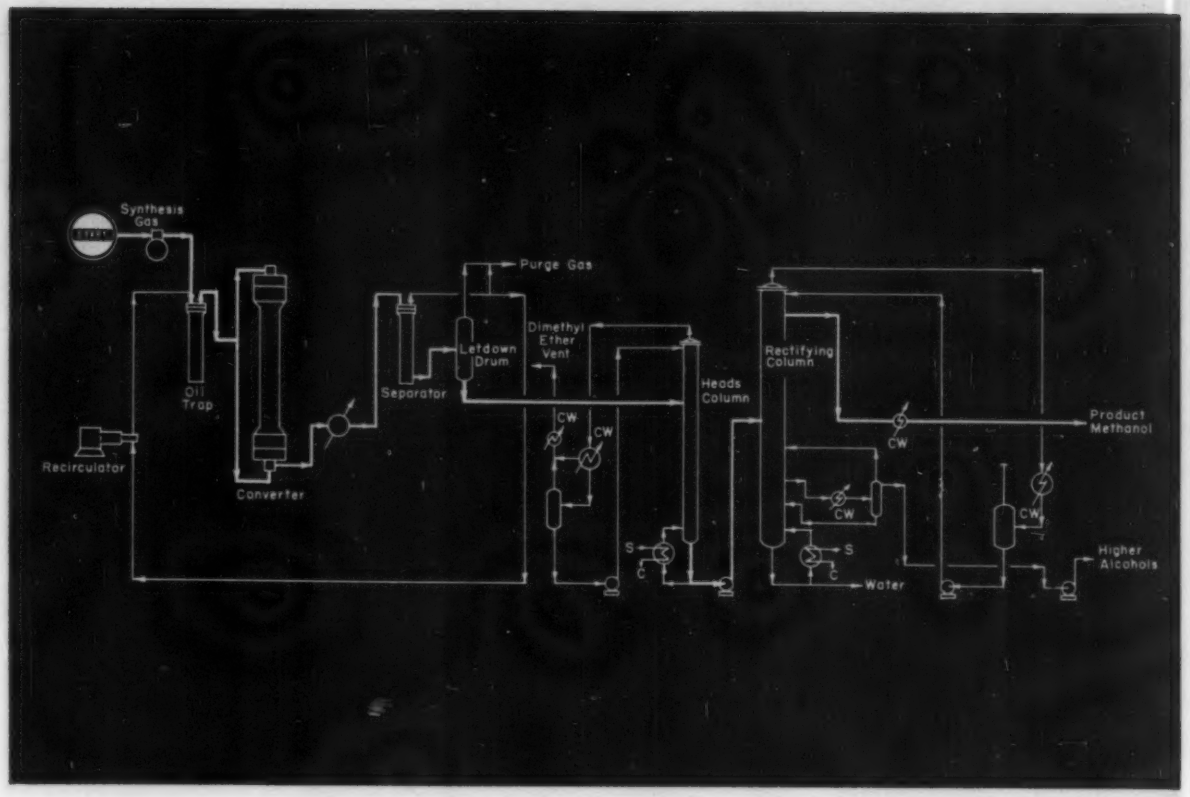
The Uhde methanol reactor consists of catalyst beds mounted in a high-pressure container. The main body of reacting gas enters at the top of the vessel and passes down along the shell through an annular space. This preheats the gas and keeps the pressure shell cool. The pressure shell is therefore constructed of heat-treated steel. A stainless steel or copper lining is used because of corrosion possible from the high partial pressure of CO. At the bottom the gas passes through the shell side of a shell-and-tube-type exchanger built within the pressure shell. Here it is heated by the reaction products leaving the convertor. Leaving the heat exchanger the feed gases pass through a central tube to the top of the reactor and then down through the first bed of catalyst.

The reaction of H_2 and CO is strongly exothermic. To regulate the temperature over the catalyst some of the feed gas by-passes the preheater. It enters directly into the space between the catalyst beds cooling the gases leaving the catalyst bed above.

The gases leaving the bottom catalyst bed pass through the tube side of the internal heat exchanger before leaving the reactor. They are then cooled with water and pass to the methanol separator where the condensed methanol is withdrawn. The unreacted gases are returned to the reactor by the recycle compressor. The methanol is depressured to an expansion vessel in which the dissolved gases are flashed and vented. It is then stabilized to remove light ends (ethers, hydrocarbons and noncondensibles). A small amount of caustic solution is added with the stabilizer feed to neutralize the acids formed as by-products.

The stabilized methanol is charged to the methanol fractionator for purification. A recycled sidestream withdrawn from the fractionator is treater with 1 percent potassium permanganate solution to remove aldehydes, etc., by oxidation. The overhead product of this fractionator is returned to the stabilizer where it joins the light ends stream. The purified methanol is withdrawn as a sidestream. Higher alcohols are withdrawn farther down the fractionator. The sodium salts, MnO_2 and water are withdrawn to waste at the bottom of the tower.

Operating Conditions: The methanol synthesis is carried out at 4,600 psig. In the catalyst beds the reacting gases enter at approximately 615° F.



Methanol (Inventa-Vulcan)— VULCAN-CINCINNATI, INC.

Application: A process for the manufacture of methanol.

Charge: Carbon monoxide or carbon dioxide and hydrogen.

Description: Methanol is synthesized by the following reactions, the first being preferred because of the lower hydrogen requirement:

$$CO + 2H_2 \rightarrow CH_3OH \quad (1)$$
$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O \quad (2)$$

Synthesis make-up gas may be prepared from a variety of raw materials, including natural gas, coal, coke, by-product gases and oil. The synthesis gas may be scrubbed with monoethanolamine to remove CO_2, or a hot carbonate system may be employed for this purpose, if CO_2 removal is necessary.

The synthesis gas is brought to about 5,500 psi in a multi-stage compressor. The gas stream passes through an oil trap, then to a converter which is filled with catalyst and which contains a tubular exchanger in its lower section.

The feed gas enters the top of the converter and flows down the outside of the catalyst bed and over the exchanger. Then it flows to the top of the converter and returns through the catalyst bed where the methanol-producing reaction takes place. The hot stream passes through the tubes of the exchanger, where heat is transferred to incoming gas, and exits from the converter. In this way incoming gas is preheated to reaction temperature.

The gaseous stream leaving the converter passes through a water-cooled exchanger and enters a separator from which condensable products, principally methanol, are drawn. Non-condensable gas leaves the top of the separator and is recirculated through a booster compressor to join fresh feed at the oil trap. Crude methanol from the bottom of the separator goes to a flash drum to be let down to approximately 400 psi before entering the finishing stage.

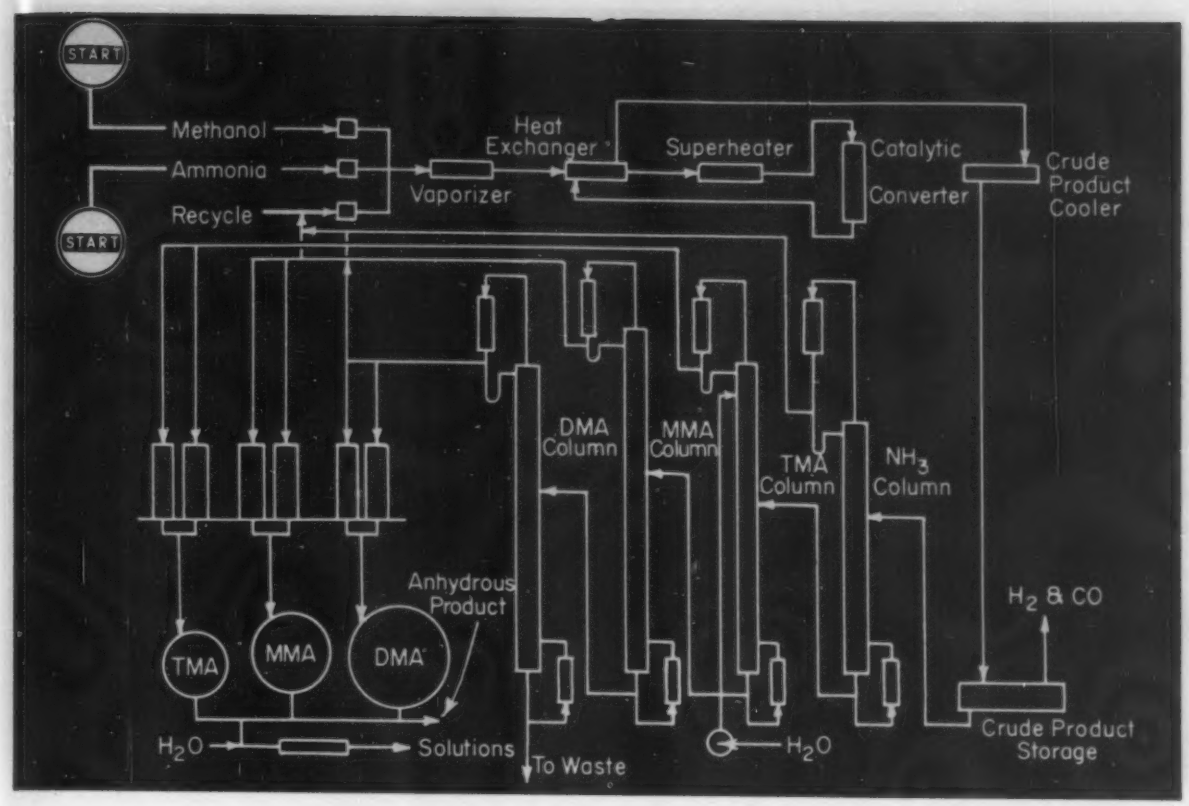
Methanol purification takes place in two distillation towers, a bubble-tray heads fractionator and a bubble-tray rectifying tower.

Low-boiling compounds and side-product dimethyl ether are taken off overhead from the first tower, crude methanol from the bottom. Then higher alcohols are taken off as heart cut from the second tower and water as bottoms. Overhead is 99.85+ to 99.95+ percent product methanol.

Of particular interest is the catalyst, which operates with high selectivity and at low operating temperatures to inhibit contaminating side reactions (e.g., formation of methane, dimethyl ether, higher alcohols). This results in an unusually pure "crude" methanol that permits a comparatively simple and inexpensive methanol finishing facility—essentially only two distillation towers. The catalyst has long life (approximately 14-18 months) and high life capacity (about 20-25 tons/methanol/liter catalyst). This sharply reduces plant downtime and labor needed for catalyst replacement. In addition, the catalyst has low volume shrinkage during operation since it is pre-reduced and can be stored for two years or longer without loss of activity. This eliminates costly shutdowns to bring the catalyst bed back up to specified volume after start-up. A particular asset during a plant's shakedown period, during which a plant may be shut down and started up frequently while getting compressors on line and training personnel, etc., is the fact that the catalyst's activity is little affected by repeated shutdowns. The catalyst has a high production rate and will not dust, break or poison easily.

Operating Conditions: As described above.

Commercial Installations: Hercules Powder Company (U.S.A.); Alba, S. A. (Brazil).



Methylamines— THE LEONARD PROCESS COMPANY

Application: A continuous process for the manufacture of mono, di, and tri-methylamines, CH_3NH_2, $(CH_3)_2NH$, $(CH_3)_3N$.

Charge: Technical grade anhydrous ammonia, and synthetic methanol.

Products: Anhydrous or aqueous solutions of mono, di, and trimethylamine.

Description: Anhydrous ammonia, synthetic methanol, and recycle liquid are fed continuously at controlled rates to a vaporizer which converts the liquid to a gas stream which then flows successively through a heat exchanger and superheater and into a converter packed with an amination catalyst where the ammonia and methanol react to form the amines. The reaction is exothermic and part of this heat of reaction is recovered by passing the hot exit gases from the converter through the heat exchanger to heat up the forward gas flow. The gas stream from the heat exchanger passes into a condenser which liquefies the stream and permits storage of the crude product until it is distilled.

From the crude product storage, the mixture of NH_3, Mono, Di, and Tri-methylamines and water are fed to four distillation columns in series. The first column separates out the excess ammonia and part of the trimethylamine which forms an azeotrope with ammonia as an overhead stream which is recycled. The bottoms are fed to the second column into which water is fed near the top to perform an extractive distillation which permits pure trimethylamine to be withdrawn overhead and taken to product storage, or recycle as desired. The bottoms are fed to the third column where pure monomethylamine is taken off as a top product stream which can be piped to storage, or recycled as desired. The bottoms are fed to the fourth column where pure dimethylamine is taken off as an overhead product while the water is drained to waste from the column bottom.

Since the reaction system is a perfect equilibrium system, any amount of the tri, mono, or dimethylamine can be taken off as product from the system, and any amount not wanted as product can be recycled, and the recycled material suppresses the formation of an equivalent amount of that material. This permits great flexibility in the operation of the plant and gives the ability of meeting peak demands for sale of various products. All three products are better than 99 percent pure.

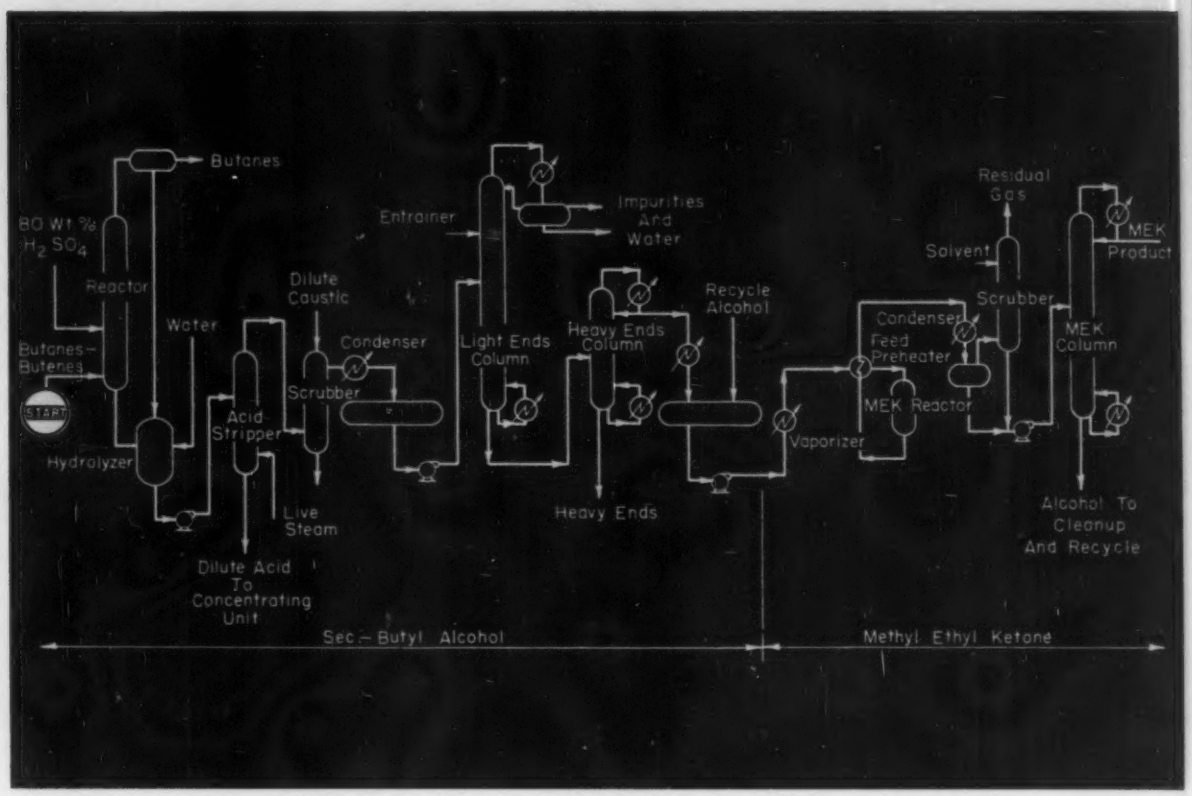
The entire operation is continuous and is instrumented so that one operator per shift controls the plant.

All process equipment and piping is fabricated of carbon steel which, since the methylamines are excellent corrosion inhibitors, lasts indefinitely.

Yields: Over-all yield of both ammonia and methanol is above 95 percent.

Commercial Installations: The Leonard Process Co., 437 Fifth Avenue, New York has two plants in operation in the United States. (Commercial Solvents Corporation and Pennsalt Chemicals Corporation and two more under design. In the Far East, Nitto Chemical Co.; in Italy, PERSEA Chemical's plant is now under construction.

Reference: PETROLEUM REFINER, Sept.1,'58,p373.



Methyl Ethyl Ketone and Acetone

Application: A process for manufacturing methyl ethyl ketone (MEK).

Charge: A mixture of butane and normal butenes (30-50 percent butenes).

Product: Methyl Ethyl Ketone (99 percent purity).

Description: Liquid butane-butene is mixed with 80 percent sulfuric acid and charged to a contacting tower. Under conditions of 2-3 atmospheres and about 100° F the acid reacts with the butenes to form butyl sulfates. The reaction is exothermic, and heat is withdrawn by external coolers or internal coils.

Conversion of butenes is practically complete. Residual butane is removed from the products in a phase separator and the acid-sulfate mixture flows to a hydrolyzer. Alcohols are formed from the sulfates, with *sec*-butyl alcohol being the principal product.

The hydrolyzate is fed to a brick-lined column where alcohols are steam-stripped from the dilute acid. Entrained acid is removed by dilute (8-10 percent) caustic scrubbing. The scrubbed vapors are then condensed to form a crude containing 10-20 percent water, light organics *sec*-butyl alcohol, and heavy ends.

The crude acid is purified in a two-column fractionation. An entrainer, such as di-isobutylene is added to the first column to form a light-boiling ternary azeotrope with water and the light impurities. Finished *sec*-butyl alcohol (95+ percent purity) is taken overhead in the second column.

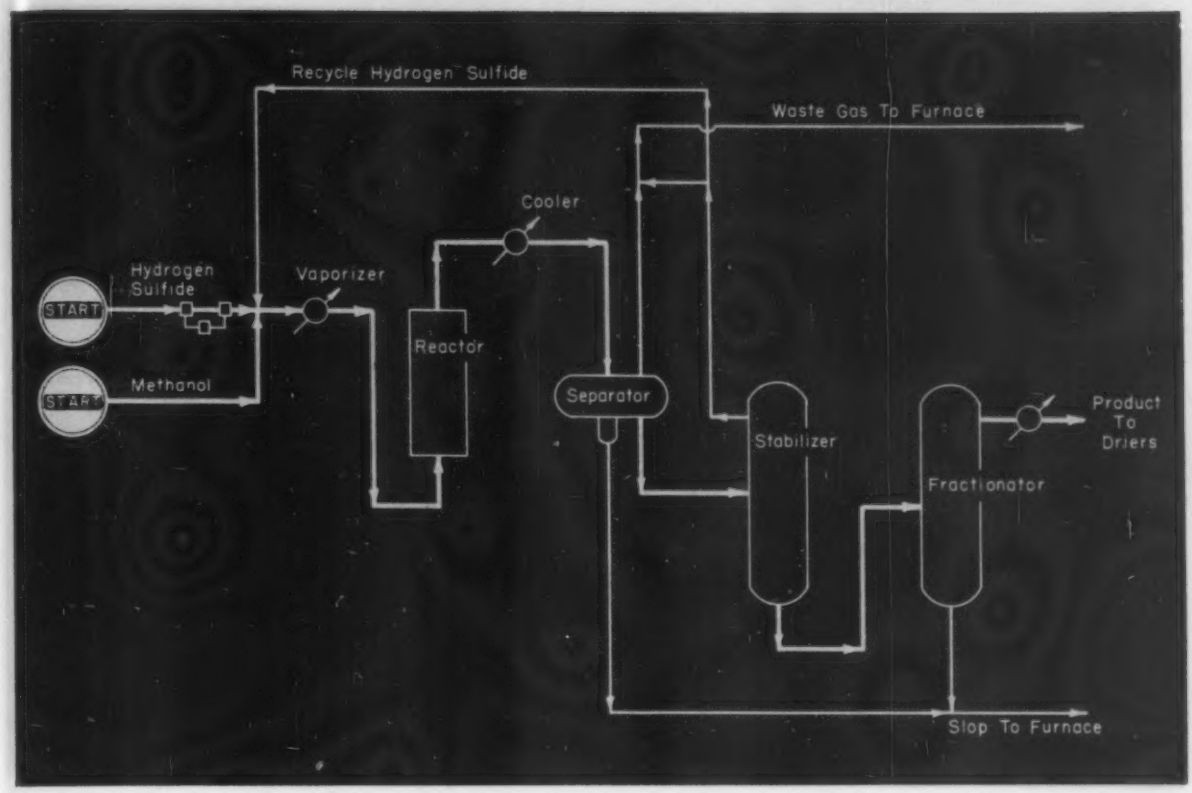
The *sec*-butyl alcohol is vaporized, preheated and charged to a tubular reactor where dehydrogenation to MEK takes place. The tubes are packed with zinc oxide catalyst and are direct-fired to maintain a reaction temperature of 700°-800° F. Conversion is controlled to minimize catalyst coking; a typical value is 75 percent.

The reactor effluent contains MEK, unconverted alcohol, hydrogen, and minor impurities. The mixture is condensed, and equilibrium amounts of MEK and alcohol removed from the residual gas by absorption in a nonvolatile solvent. Product MEK is taken overhead in a final distillation column.

Acetone is made from isopropyl alcohol in a similar manner. Dehydrogenation occurs over a zinc oxide catalyst at 750°-850° F.

Yields: Over-all process yield, MEK from butene, is 75-80 percent.

Commercial Installations: This process or a variation is used for making MEK at the following locations: Esso Standard Oil Co., Linden, N. J.; Shell Chemical Corp., Dominguez, Calif., Houston (Deer Park), Texas, Martinez, Calif.



Methyl Mercaptan— AMOCO CHEMICALS CORPORATION

Application: A process for the manufacture of methyl mercaptan.

Charge: Raw materials to this process are methyl alcohol and hydrogen sulfide.

Product: Methyl Mercaptan (98 mole percent pure).

Description: The fresh hydrogen sulfide feed is compressed and combined with a recycle hydrogen sulfide stream from the fractionation section. Methanol is injected into the combined hydrogen sulfide stream, and the total feed is vaporized before entering the fixed-bed reactor. The reactor effluent is partially condensed and flows to the separator drum where three phases are separated: a vapor phase, a water phase, and a lighter mercaptan-rich phase.

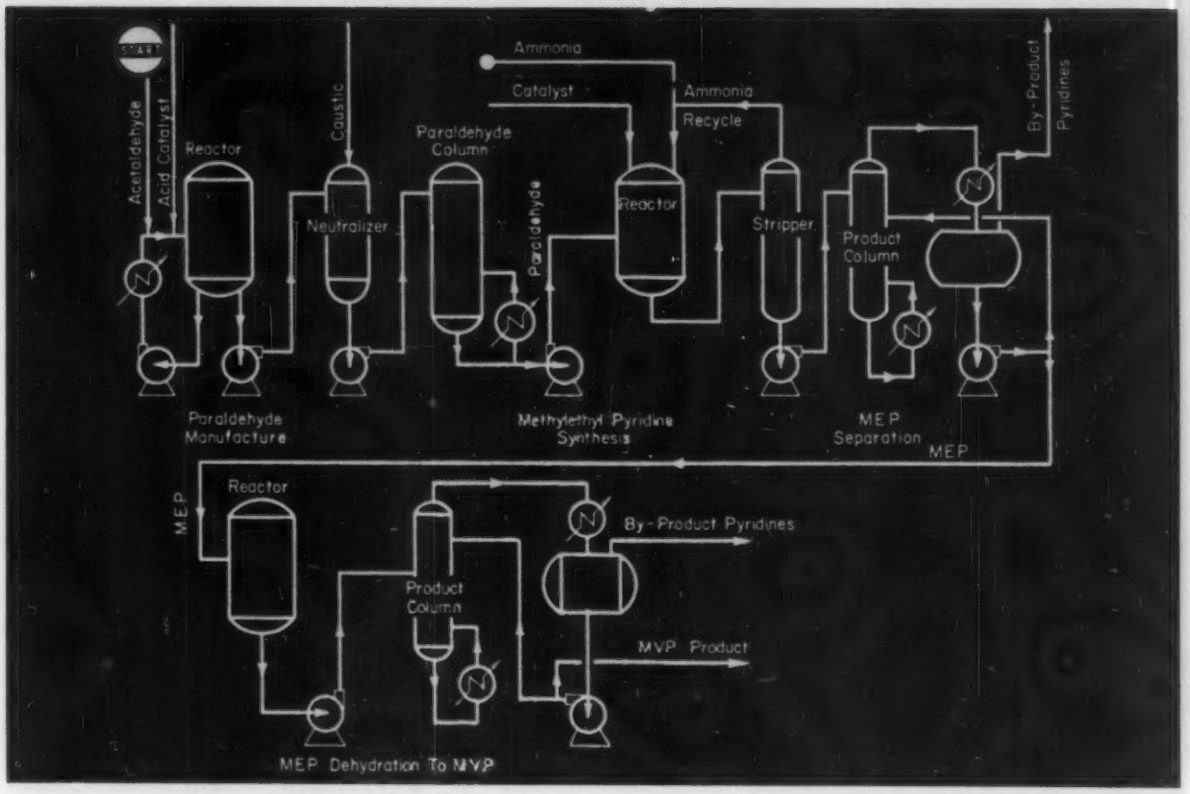
The gas phase consisting largely of light hydrocarbons and carbon dioxide received in the hydrogen sulfide feed is vented to the waste furnace. The mercaptan phase is separated by decantation and pumped to the stabilizer column, where the unreacted hydrogen sulfide, together with reaction byproducts and other components lighter than methyl mercaptan are removed and recycled to the reactor feed. A part of this stream is discarded to the waste system as necessary to control the concentration of light contaminants in the system.

Bottoms from the stabilizer tower is charged to the second tower where the methyl mercaptan product is taken overhead and dried. The bottom stream consisting principally of dimethyl sulfide, ethyl and isopropyl mercaptan, water and unconverted methanol is run down to the waste disposal furnace.

The synthesis step of the production of methyl mercaptan is carried out at a temperature of 600°-625° F and a pressure of 300-350 psig over alumina catalyst. The molar yield of methyl mercaptan on methanol is 64-71 percent.

Because of toxicity and obnoxious odor, both the hydrogen sulfide feed and methyl mercaptan product present handling problems. A waste disposal furnace is provided to burn all byproduct streams.

Commercial Installation: This process for making methyl mercaptan has been in use since 1955 at the Texas City plant of Amoco Chemicals Corporation.



Methyl Vinyl Pyridine

Application: This process is for the manufacture of methyl vinyl pyridine.

Charge: Acetaldehyde and ammonia.

Product: The product is methyl vinyl pyridine.

Description: The first step in the synthesis is to convert acetaldehyde into paraldehyde. This is done by trimerization of three moles of acetaldehyde to one mole of paraldehyde in the presence of sulfuric acid and catalyst.

$$3\ CH_3\ CHO \xrightarrow[\text{Catalyst}]{H_2SO_4} (CH_3\ CHO)_3$$

This polymerization is continuous with make-up acetaldehyde and sulfuric acid being fed continuously to the reactor. An external heat exchanger is used to remove the heat of reaction. Before purification by fractionation of the paraldehyde for the Methyl Ethyl Pyridine (MEP) synthesis the acid is neutralized by addition of caustic.

The liquid phase reaction of paraldehyde with ammonia proceeds as follows:

$$1\tfrac{1}{3}\ (CH_3CHO)_3 + NH_3 \rightarrow \text{(5-ethyl-2-methyl pyridine)} + 4\ H_2O$$

Along with MEP a certain amount of 2-picoline, 4-picoline and heavy pyridines are formed. Ammonia in excess of theoretical requirements is used.

Crude product is next sent to the separation section and the various pyridine recovered as technical grades. Excess ammonia is recycled and certain fractions sent back for rerun. MEP fraction is transferred to intermediate storage before going to the Methyl Vinyl Pyridine (MVP) synthesis section.

MEP is recovered as a clear liquid of 345°-356° F boiling range at atmospheric pressure. MEP has other end uses than the manufacturing of MVP.

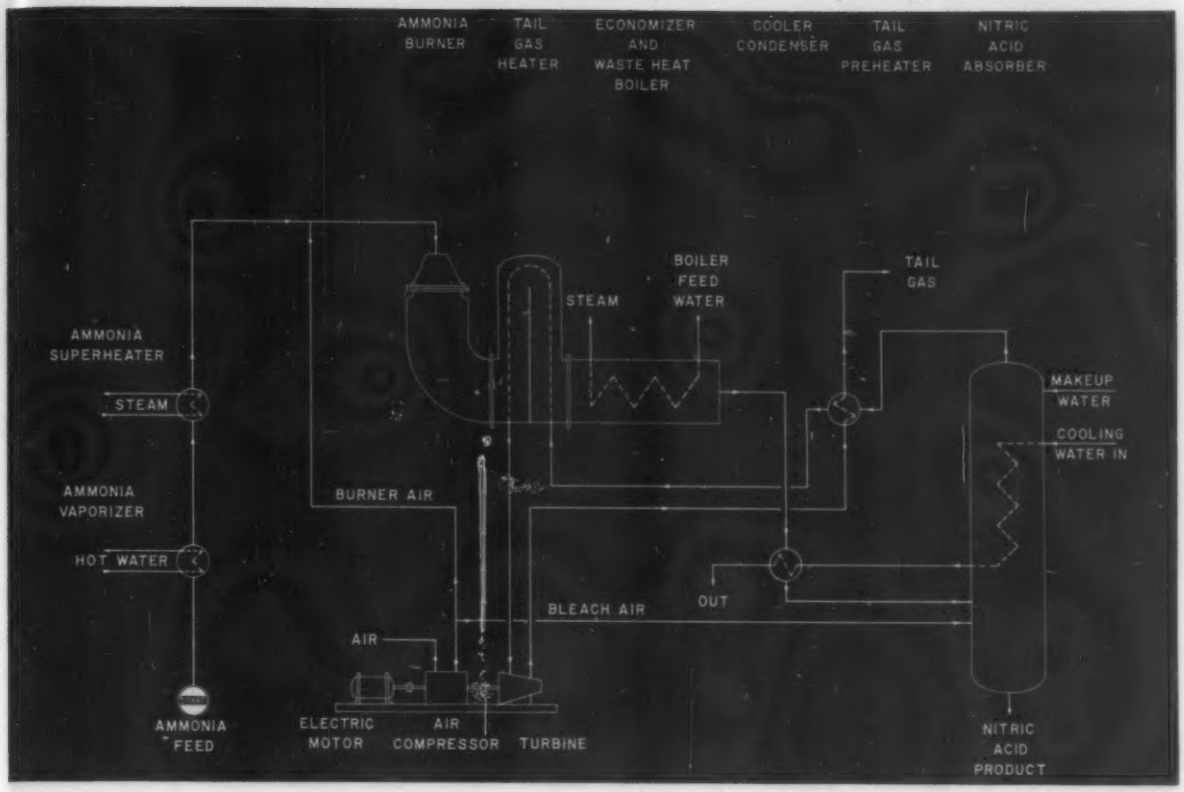
MEP dehydrogenation to Methyl Vinyl Pyridine proceeds as follows:

$$\text{(5-ethyl-2-methyl pyridine)} \xrightarrow{\text{Catalyst}} \text{(2-methyl-5-vinyl pyridine)} + H_2$$

Along with the main product MVP (2-methyl-5-vinyl pyridine) certain by-products are also produced as in the methyl ethyl pyridine synthesis. MVP is recovered as a final product.

Commercial Installations: A plant using a process similar to this is operated by Phillips Chemical Company, Adams Terminal, Houston.

Reference: *Petroleum Processing,* Dec.1952,p1802.



Nitric Acid (Uhde)—ARTHUR G. McKEE AND COMPANY

Application: A process for producing nitric acid.

Charge: Anhydrous ammonia, atmospheric air, and make-up water.

Product: 55-60 percent nitric acid.

Description: The Uhde nitric acid process produces nitric acid by the catalytic oxidation of ammonia to nitric oxide with subsequent oxidation and absorption of nitrogen oxides in water.

In the process, liquid ammonia is vaporized, superheated and mixed with compressed air prior to being fed to the ammonia burner. Compressed air is supplied by a centrifugal compressor driven by a gas expander with make-up power provided by an electric motor or alternately by a steam turbine. The reaction mixture consisting of 10.5 percent ammonia by volume is oxidized over a platinum-rhodium gauze catalyst to produce nitric oxide. The reaction is highly exothermic, liberating about 3 mm BTU/ton HNO_3, and takes place at a temperature of 1710° F when the reactants have been preheated to about 450° F. Ninety-five percent of the ammonia is converted to nitric oxide, the remainder is consumed by side reactions.

The reaction gases from the burner are cooled sequentially by heating tail gas for the expander in the tail gas heater, generating steam in the waste heat boiler, and finally partially condensed in the cooler condenser prior to being fed to the nitric acid absorber. Additional heat is liberated in the exchange train by the oxidation of about 50 percent of the nitric oxide to nitrogen dioxide. Platinum losses are minimized by filtering the reaction gases.

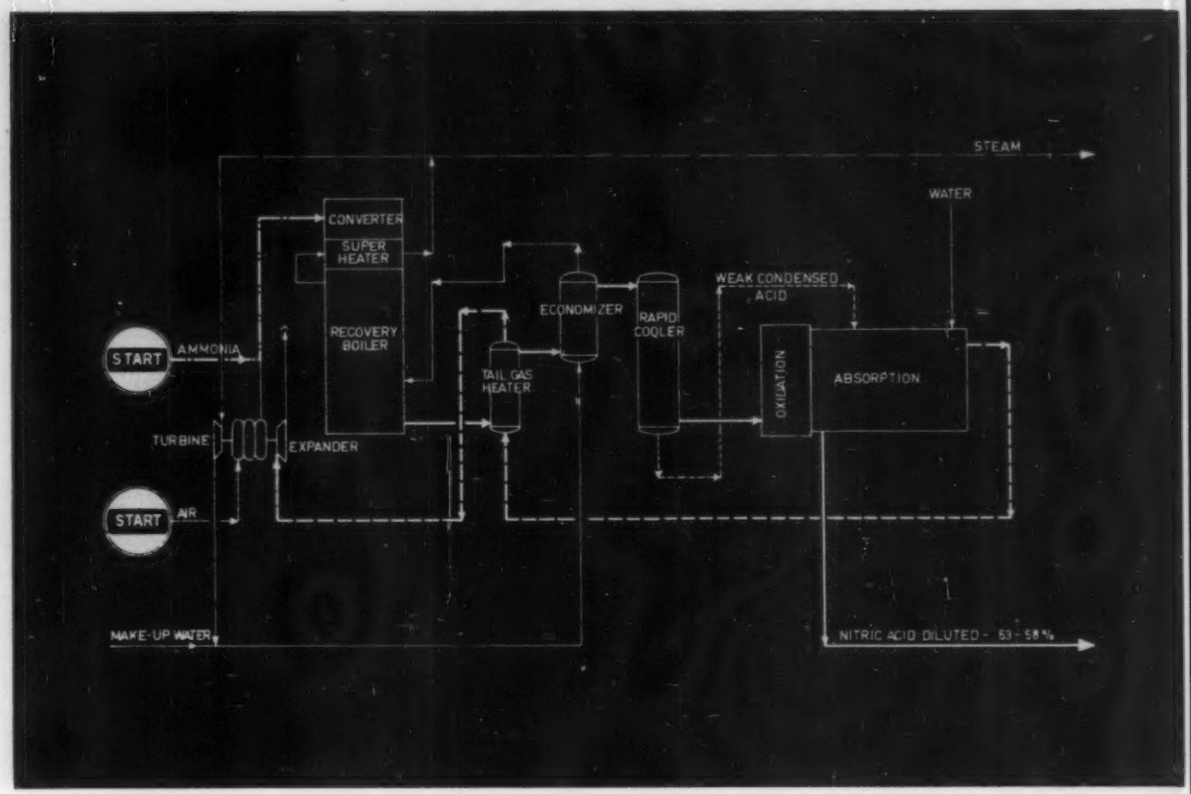
The feed to the absorber consists of a weak nitric acid solution and a partially oxidized acid gas. In the nitric acid absorber, nitric oxide is further oxidized to nitrogen dioxide and absorbed in water to form the nitric acid product. In the design of the nitric acid absorber, care must be taken to provide residence time for the oxidation of nitric oxide, since it is a slow reaction. Cooling coils are provided as an integral part of the tower since the oxidation of nitric acid and the absorption of nitrogen dioxide are both exothermic. The nitric acid product is bleached with secondary air from the compressor to remove dissolved oxides and produce a water-white product. Acid concentrations of 55 to 60 percent may be made by adjusting the make-up water to the absorber.

The tail gas from the absorber is preheated by the expanded tail gas from the turbine in the tail gas preheater. The preheated tail gas is heated to 950° F in the tail gas heater and expanded through the turbine to recover power. The expanded tail gas is further cooled by preheating the cold tail gas from the nitric acid absorber prior to being vented to atmosphere.

Operating Conditions: The operating variables are system pressure, burner temperature, and absorption temperature. Burner temperatures in the order of 1,700° F to 1,715° F provide optimum conversion without excessive catalyst losses. The nitric acid absorber is provided with internal cooling coils, in order to maintain an absorption temperature of about 100° F. High pressures are favorable for absorption. Pressures of about 90 to 100 psig at the absorber are customary.

Yields: The over-all yield of ammonia to nitric acid is 93.5 percent.

Commercial Installations: Co-op Farm Chemicals, Lawrence, Kansas and several European installations.



Nitric Acid— MONTECATINI

Application: This is a process for the manufacture of nitric acid aqueous solution by ammonia oxidation and subsequent absorption of the obtained nitrogen oxides in water.

Charge: Anhydrous, gaseous ammonia and air.

Product: Nitric acid aqueous solution, 53-58 percent by weight, containing 5 ppm maximum of HNO_2 as impurities.

Description: A mixture of carefully filtered, compressed and unpreheated air and pure gaseous ammonia is catalytically oxidized in the presence of platinum wire in a converter to nitrogen oxides. The reaction heat is removed in a boiler embodied in the same shell together with a superheater for the generated steam. The reacted gases then flow through a tail gas heater, an economizer in which water feed for the boiler mentioned above is preheated, and a rapid cooler. Here almost complete condensation of steam present in the reacted gases occurs, thus allowing oxidation of NO to NO_2 to be performed in the presence of the proper amount of water. Oxidation of NO and absorption of NO_2 in weak condensed acid plus make up water is carried out in cascade absorbers from which the final product is withdrawn. Tail gases, heated in an exchanger at the expense of heat contained in the reacted gases, reach an expansion device coupled to the compressor for the incoming air. The same compressor is driven also through a turbine by superheated steam generated in the primary cooling of reacted gases. Thus the whole plant is completely self-sufficient as far as mechanical power is concerned.

Operating Conditions: The plant is usually operated at a pressure of 36 to 43 psi, at which maximum combustion yields are obtained. Regarding temperatures, the optimum temperature chosen by Montecatini in its converter is in the range of 1,500° F since this represents the optimum condition between two opposite parameters, namely conversion efficiency, which could be higher at higher temperatures, and platinum losses which also increase as temperature increases.

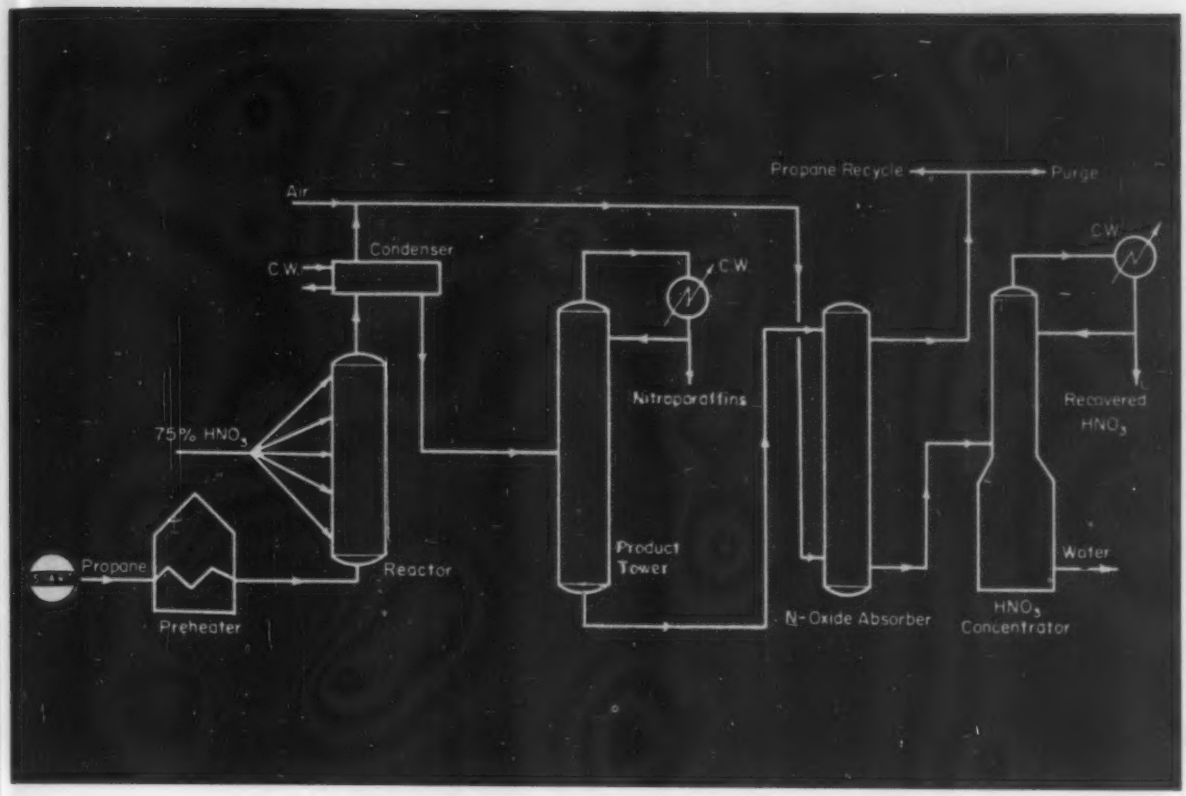
Many other advantages are obtained by means of this combination of operating conditions, covering both installation costs and operational expenses.

Yields: The over-all efficiency of plants of the kind described is 94 percent. Heat is recovered in the form of steam, on the basis of 5-6 tons per ton of ammonia used in the converter.

Commercial Installations: 46 nitric acid plants have been engineered and erected by Montecatini in 13 different countries. Of these plants, only 8 are in Italy and the remaining 38 are abroad. The biggest is the plant located at Ferrara, Italy, with a total capacity of 160,000 metric tons/year of 53 percent product.

A plant of this kind was erected in 1956 in the United States at Geneva, Utah, for U.S. Steel Corporation, and has a capacity of 100,000 metric tons per year of 53 percent acid.

Reference: *Chem. Engineering,* May5,'58,p56.



Nitroparaffins

Application: A process for the manufacture of nitroparaffins from propane.

Charge: Propane and 75 percent nitric acid.

Products: Nitromethane, nitroethane, 1-nitropropane, and 2-nitropropane.

Description: Propane gas is heated to 430°-450° C in a furance and enters a glass or silica-lined reactor. The 75 percent nitric acid is sprayed into the gas stream at several points. The amount of acid from each spray is adjusted so that the heat of vaporization of the water in the acid counteracts the exothermic heat of the reaction to maintain the temperature at 390°-440° C. The over-all mole ratio of propane: nitric acid is 5:1, with the stagewise addition limiting the ratio at any one stage to 25:1.

It is important that pyrolytic temperatures be avoided in order to prevent carbon skeleton rearrangements. At the proper nitration temperatures some decomposition of the various nitrated and oxidized compounds does not occur and therefore some olefins and degrated products are formed. The pyrolysis of nitroethane and 1-nitropropane gives olefins, aldehydes, carbon dioxide, and nitrogen.

Nitric acid and nitrogen dioxide give the same products, but nitric acid gives better yields and higher nitration rates. Comparison of various reaction rate studies shows that the substitution of any hydrogen atom can be effected more readily by nitric acid than by nitrogen dioxide. Some experimental runs show four times the yield using nitric acid rather than nitrogen dioxide.

The gas leaving the reactor is cooled in a partial condenser. The nitroparaffins and dilute nitric acid are condensed while propane and gaseous oxidation products pass to recovery units from which recovered propane is recycled. The condensate separates into two layers. The lower dilute nitric acid layer is fed back to the nitrator as makeup, after fortification with fresh nitric acid. The upper nitroparaffin layer is fractionated into the four products of the reaction.

Under the conditions of the reaction the products obtained will represent all possible ones in which the nitro group replaces either a hydrogen or any alkyl group in the hydrocarbon feed. Close control of the reaction is necessary to avoid excessive losses by oxidation.

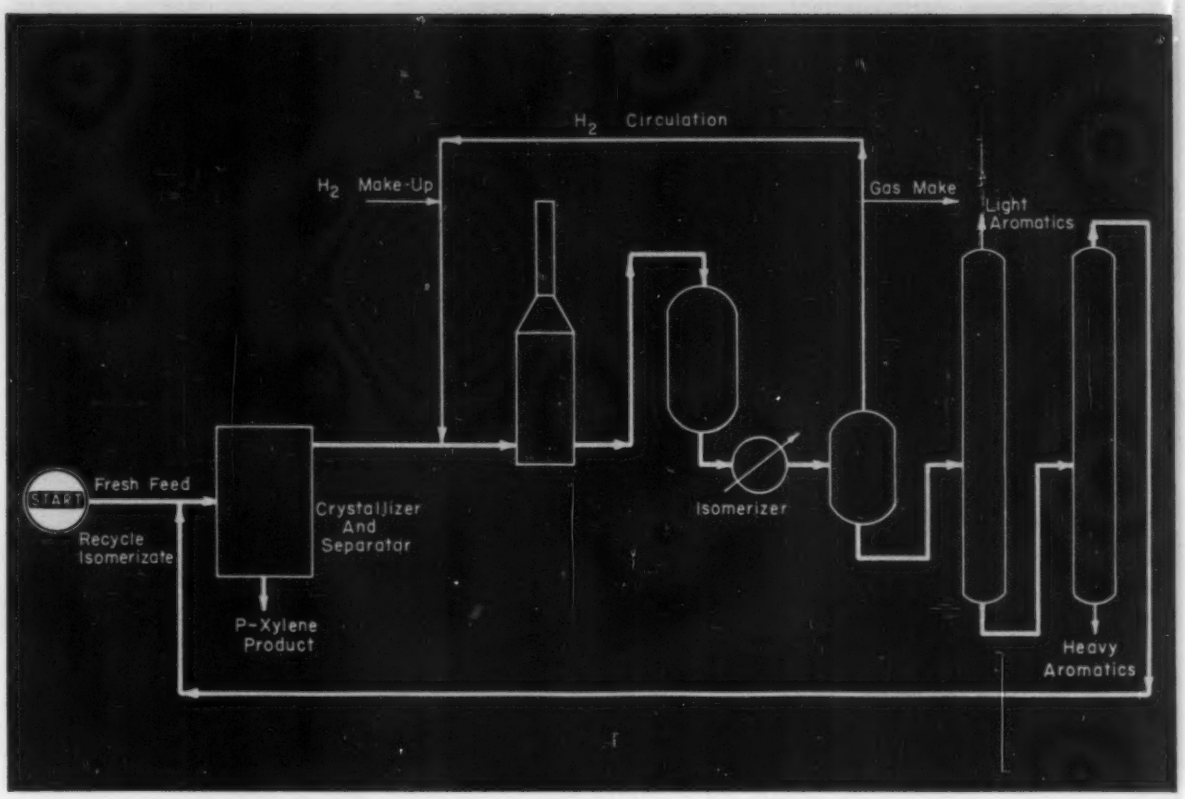
Yields: Yields of 40 percent per pass based on nitric acid conversion to nitroparaffin are reported.

EFFECT OF TEMPERATURE ON PRODUCTS NITRATING PROPANE

PRODUCT	500-510° C. Mole %	790-800° C. Mole %
Nitromethane	22.0	32.2
Nitroethane	16.6	24.2
1-nitropropane	13.2	24.2
2-nitropropane	48.2	19.3

Commercial Installation: This process is in commercial use by Commercial Solvents Corporation at Peoria, Ill.

References: Hass and Schechter, *Industrial and Engineering Chemistry*, **39**,p817 (1947). P. H. Groggins (Ed.), *Unit Processes in Organic Syntheses*. 4th Edition,pp2-14 and 77-79. New York, McGraw-Hill Publishing Co., 1952.



Octafining— THE ATLANTIC REFINING COMPANY

Application: A process for making any selected xylene.

Charge: Mixed C_8 aromatics in non-equilibrium concentrations.

Product: *Ortho-*, *meta-* or *para*-xylene, as desired.

Description: The Octafining process operates on mixtures of C_8 aromatics to bring their concentrations toward an equilibrium value. Therefore, the quantity available of any one of the xylenes can be increased by charging to the Octafining process a mixture of C_8 aromatics in which the concentration of the desired xylene is below the equilibrium value for it in the mix. The Octafining catalyst contains platinum on a silica-alumina support.

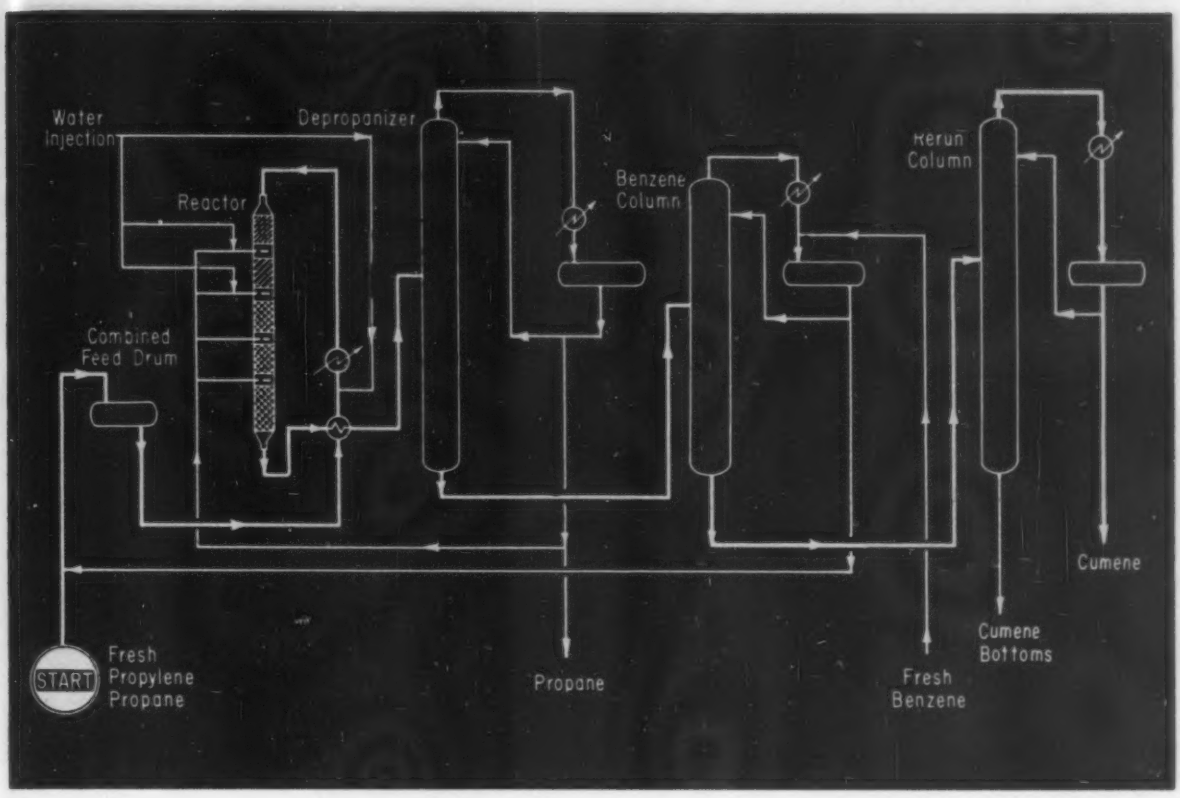
An example of a practical application is to maximize *para*-xylene yield from a mixed C_8 aromatics feed which otherwise would have only a solvent value. In this application, the C_8 aromatics from catalytic reforming and as recycle from the Octafining process would have *p*-xylene removed by crystallization, to give a filtrate containing 7-9 percent *p*-xylene. This filtrate would be mixed with recycle hydrogen and some make-up hydrogen, heated to 750°-950° F at 150-350 psig and passed through Octafining catalyst in the single reactor. Isomerization within the Octafining reactor brings the *p*-xylene content back to its equilibrium value of about 19 percent. Following the Octafining reactor, the isomerizate is cooled, hydrogen separated for recycle and aromatics below and above C_8 removed by fractionation. The remaining C_8 mixture is recycled to join fresh feed ahead of the crystallization. If it should be desired to maximize *ortho-* or *meta*-xylene, a separation step appropriate to the desired isomer would replace the crystallization which in the above example was used to separate the *para*-xylene.

Atlantic's laboratory work indicates that the Octafining catalyst can be used also on C_9 aromatics to isomerize cumene into trimethylbenzene and methylethylbenzene under appropriate operating conditions.

From the discussion above it is readily evident that the yield from a specific application of the Octafining process will be dependent on the composition of the feed, the product desired and the effectiveness of the separation step.

Commercial Installations: The Octafining process, which was developed by The Atlantic Refining Company, will be licensed by Engelhard Industries, Inc., who also will supply the catalyst. An Atlantic Octafiner is being built for Mitsui Petrochemical Industries, Ltd. In conjunction with its crystallizer, it has a rated capacity of 11 million pounds of *p*-xylene per year.

Reference: *Ind. Eng. Chem.*, Vol. 47'55,p770-3. PETROLEUM REFINER, Aug.,'58,p208.



Olefin-Aromatic Alkylation— UNIVERSAL OIL PRODUCTS COMPANY

Application: A process for alkylating aromatics with olefins. Its principal application is in the manufacture of cumene (isopropylbenzene) by reacting propylene with benzene. The process also is used to make ethlybenzene by alkylating benzene with ethylene. Polymers of propylene (trimer, tetramer, etc.) may be produced by excluding benzene from the feed.

Charge: Propylene-propane mixture and benzene to produce cumene; ethylene-ethane mixture and benzene to make ethylbenzene; propylene-propane mixture to make propylene polymers.

Process Description: The following description employs the manufacture of cumene as an example.

The olefinic stock is mixed with the benzene in a combined feed surge drum. The resulting charge is pumped to the reaction chamber. The catalyst, solid phosphoric acid, is maintained in separate beds in the reactor, suitable propane quench being provided between beds for temperature control purposes, since the reaction is exothermic in nature.

The reactor effluent is depropanized. Some of this propane is used for quenching; the balance is withdrawn as a net product stream.

The depropanizer bottoms stream passes to the benzene recovery column, where unreacted benzene is distilled overhead. It ultimately combines, as recycle, with fresh benzene in the overhead receiver. The fresh and recycle benzene mixture is then pumped from this receiver to the combined feed surge drum.

The crude cumene product from the bottom of the benzene column is rerun to produce specification cumene. A minor amount of cumene bottoms also is made.

Essentially the same sequence of operating steps is employed in the manufacture of ethylbenzene. However, minor modifications are necessary, as the consequence of the introduction of ethane and other light, non-condensable gases with the olefin feed. Process equipment, arranged for the most part as in the flow diagram shown, also is suitable for making diisopropylbenzenes and butylbenzenes. Appropriate modifications to the reaction conditions are required to produce these other alkylaromatics.

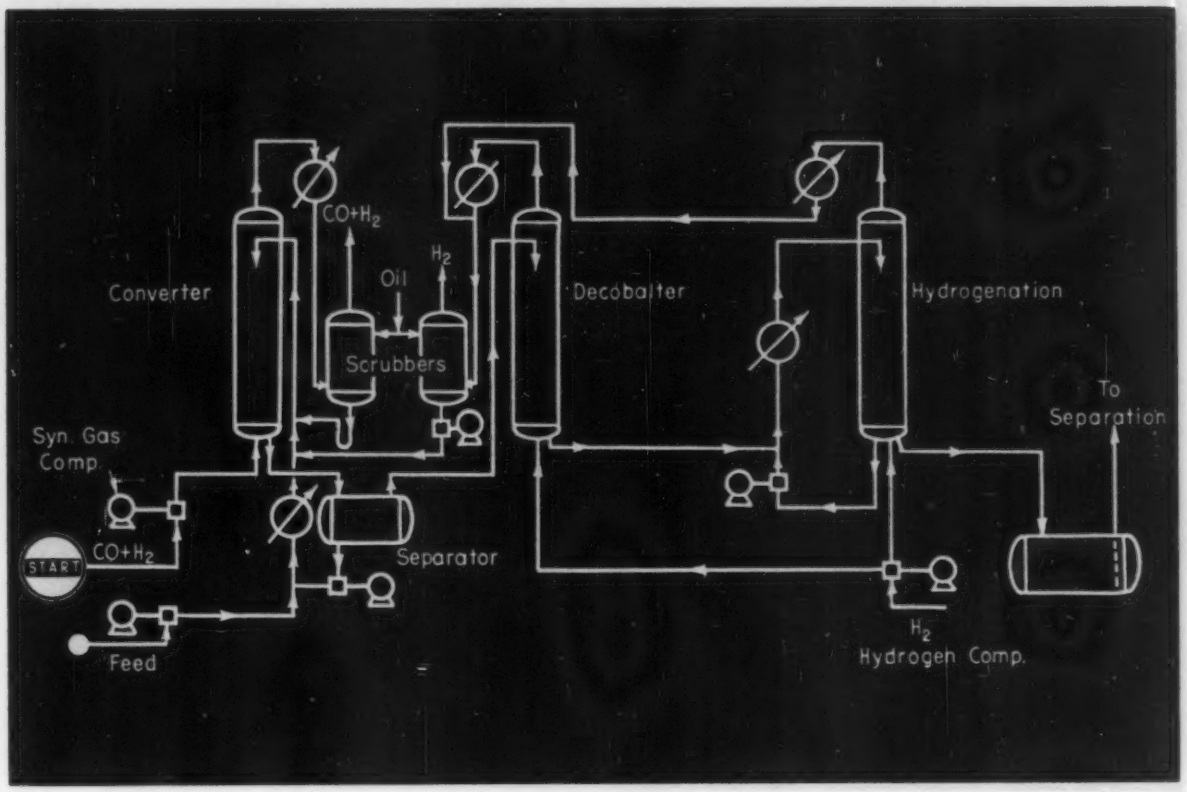
When polypropylenes are desired, the process conditions are changed, benzene is excluded from the feed and the benzene column becomes a recycle column to remove light polymer (such as dimer or trimer) either for recycle to the reactor or withdrawal from the system as net light polymer product. The crude polymer bottoms (such as tetramer) then are rerun to produce a specification product by rejecting the small amount of heavy polymer which may be present. When trimer is the desired product, additional fractionation is required, the complexity of which is determined by the specifications to be met by the product.

Yields: The yields from typical cumene and tetramer operations, respectively, are:

CUMENE OPERATION		TETRAMER OPERATION	
	BPSD		Volume Percent
Propane charge	75	Propane charge	49.3
Propylene charge	70	Propylene charge	50.7
Benzene charge	72	Tetramer, 350-480°F	29.1
Propane product	75	Heavy polymer	1.3
Propylene product	2	Light polymer	0.3
Cumene	109	Propane	54.6
Bottoms	4.5		

Commercial Installations: There are many installations employing this process. Numerous units produce cumene of high purity (over 99.4 percent) for subsequent use in manufacturing phenol and acetone. Still others have been constructed to make ethylbenzene. Many units are employed in making propylene tetramer, an important starting material in producing synthetic detergents.

Reference: Jones, E. K., "Polymerization of Olefins from Cracked Gases," p. 219-238, *Advances in Catalysis*, VIII, Academic Press, New York (1956).



Oxo Process

Application: A process for the production of aldehydes (*oxo reaction*) and alcohols (*oxo process*) from olefins.

Charge: Carbon monoxide, hydrogen, olefin and a cobalt catalyst.

Product: Saturated aldehydes containing one more carbon atom than the olefin feed stock and the corresponding alcohols (by hydrogenation).

Description: The synthesis gas (CO and H_2) is compressed to converter pressure (100-300 atms.) and introduced to the converter along with an olefin feed containing a cobalt catalyst. The overhead from the converter is cooled, scrubbed and recycled or vented. The reaction products go to a separator then to the decobalter. Hydrogen may be introduced at the bottom of the decobalter and either vented or scrubbed for recycle to the synthesis gas feed. The decobalted product is fed to the hydrogenator. The product from the hydrogenator is cooled, separated, scrubbed and distilled. The excess hydrogen is recycled. The hydrogenation step converts the initially formed aldehydes to the corresponding alcohols. The hydrogenation step is omitted if aldehydes are the desired product.

Operating Conditions: *Oxo Reaction*: Synthesis gas (H_2/CO ratio), 1.1:1; catalyst, 2.5 wt. percent cobalt naphthenate; temperature 175° C; pressure, 200 atms.; olefin conversion, 81 percent. *Decobalting*: Temperature, 150° C; pressure, 6 atms. *Hydrogenation*: Temperature, 200° C; pressure 200 atms. *Product*: For a heptene feed, 75 percent isooctyl alcohol, 25 percent bottoms.

Reactions: A typical *oxo reaction* is the production of C_4 aldehydes from propylene.

$$CH_3CH=CH_2 + CO + H_2 \rightarrow \underset{40\%}{CH_3\overset{CH_3}{\overset{|}{C}}HCHO} + \underset{60\%}{CH_3CH_2CH_2CHO}$$

The ratio of products can be varied by changing operating conditions.

The production of isooctyl alcohol from heptene (propylene-butylene dimer) is typical of the *oxo process*.

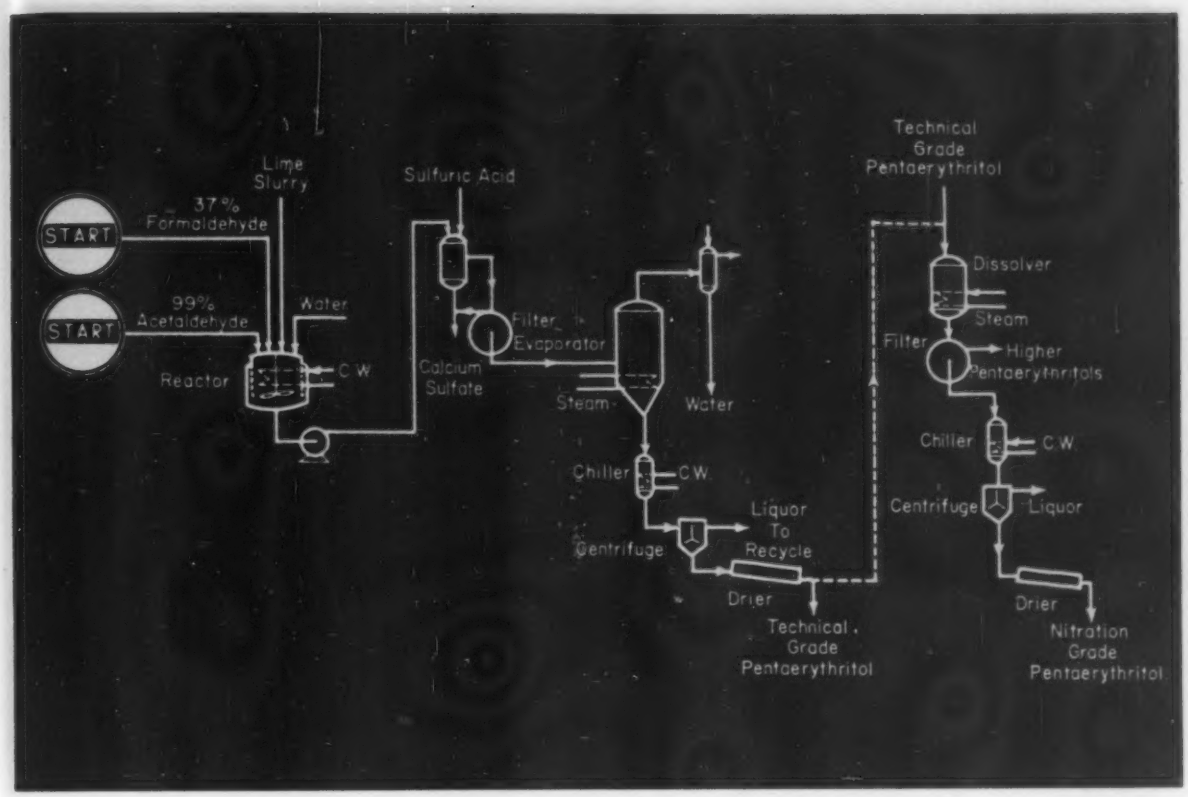
$$C_7H_{14} + CO + H_2 \rightarrow \text{Aldehydes} \xrightarrow{H_2} \text{Alcohols}$$

The alcohol composition is

3,4-dimethyl-1-hexanol	20%
3,5-dimethyl-1-hexanol	30%
4,5-dimethyl-1-hexanol	30%
3-methyl-1-heptanol and 5-methyl-1-heptanol	15%
unidentified	5%

Commercial Installations: Esso Standard Oil Company, Baton Rouge, La.; Gulf Oil Company, Port Arthur, Texas; Tennessee Eastman Company, Longview, Texas; Union Carbide Chemicals, Texas City, Texas; Amoco Chemicals, Wood River, Ill.

References: PETROLEUM REFINER, Dec.'54,p141; Dec.'56,p197; Aug.'57,p.141. *Chem Eng. News*, 33 (7), 594, Feb. 14, 1955; *ibid.*, 35(11), 16, March 18, 1957. "Higher Oxo Alcohols," John Wiley & Sons, Inc., New York, 1957. *Petroleum Week*, May 22, 1959, p. 28.



Pentaerythritol

Application: A process for manufacture of pentaerythritol, $C(CH_2OH)_4$.

Charge: Formaldehyde, 37 wt-percent aqueous solution; acetaldehyde, 99+ percent purity.

Product: Crystalline pentaerythritol, either technical grade (85-90 percent purity) or nitration grade (99 percent purity).

Description: Pentaerythritol is produced commercially by either a batchwise or continuous reaction between formaldehyde and acetaldehyde in an alkaline medium. The process description following describes the commonly-used batchwise process with lime as the alkali.

Chemically, two successive reactions take place in the manufacture of pentaerythritol. In the first, an alkali-catalyzed aldol condensation produces pentaerythritose:

$$3\,HCHO + CH_3CHO \xrightarrow{OH^-} C(CH_2OH)_3CHO$$

In the second step, the alkali enters the reaction process, and monopentaerythritol is formed.

$$HCHO + C(CH_2OH)_3CHO + Ca(OH)_2 \rightarrow$$

$$C(CH_2OH)_4 + Ca(COOH)_2$$

In practice, both reactions occur during a single batch operation. The reactor is of conventional design, being equipped with cooling coils and jacket, and mechanical agitator.

Weighed amounts of formaldehyde solution and lime slurry are placed in the reactor, the amount of lime being 10-15 percent in excess of that required stoichiometrically. Water is then added to adjust the formaldehyde concentration to about 15 percent. Liquid acetaldehyde is next introduced beneath the liquid surface, agitation and cooling being controlled to give a mixing temperature of 70°-80° F. The acetaldehyde addition is complete when the formaldehyde: acetaldehyde molar ratio is 4.5-5.0 to 1.0.

The reaction is carried out for about two hours, with the temperature being varied from 80° to 120° F. Careful attention must be given to the time-temperature relationship in order to ensure a product of good quality and yield. Overheating causes formation of complex sugars which contaminate the product. Underheating causes uneconomically-long reaction times and inadequate yields. Although in this discussion lime is considered as the alkali in accordance with general practice, caustic soda is also used.

When the reactor contents show a total aldehyde concentration of less than 0.1 percent, they are pumped to the neutralizing tank where dilute sulfuric acid is added to lower the pH to about 8.0. This precipitates calcium sulfate, which is in turn filtered off. (If sodium hydroxide is used in the process, neutralization is effected by formic acid and this filtration step is not required, since the sodium formate is soluble.)

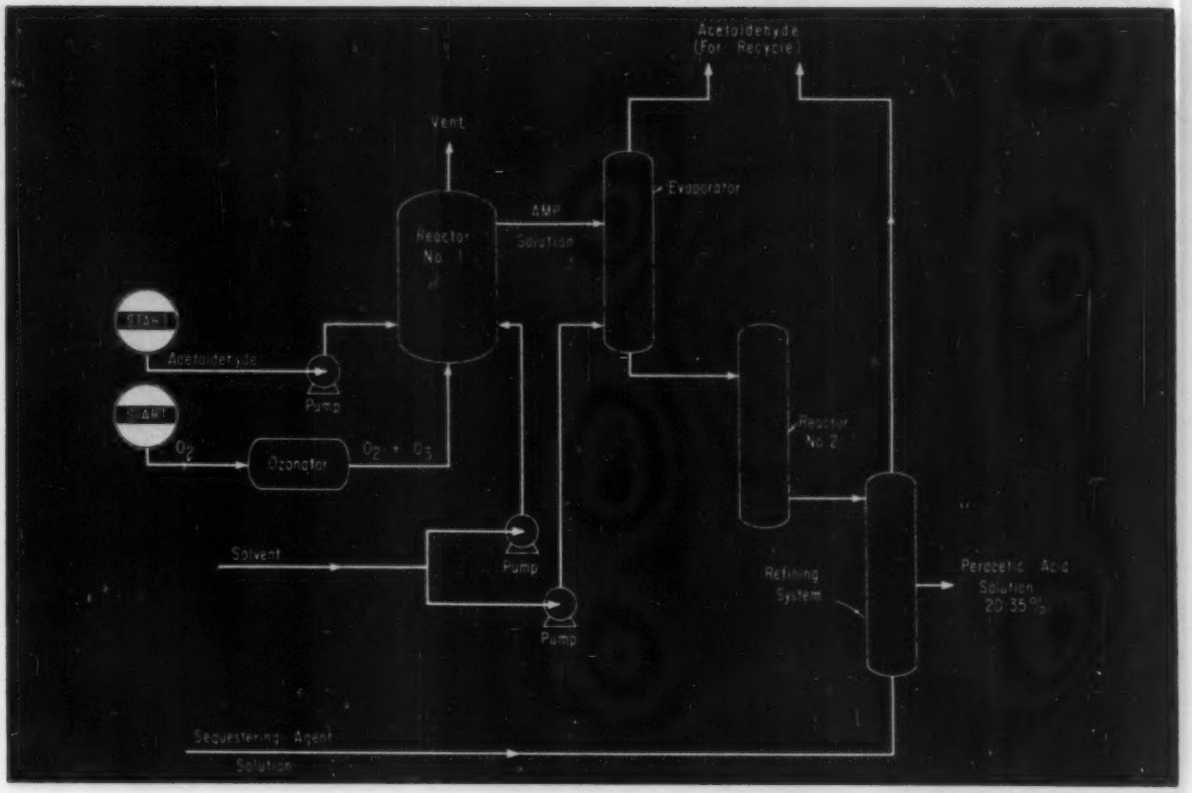
The filtrate passes to a vacuum evaporator where most of the water is removed. The thick liquor has a specific gravity of about 1.27 and contains some precipitated pentaerythritol. Precipitation is completed in a water-cooled vessel, and the crystals separated by centrifuging. The mother liquor is recycled to the evaporator for further recovery of penetaerythritol. The moist crystals are dried to yield technical grade product, which contains 85-90 percent monopentaerythritol with dipentaerythritol as the principal impurity. Some 80 percent of the industrial production of pentaerythritol is technical grade.

For the production of nitration-grade material, it is necessary to remove virtually all of the poly-pentaerythritols. To do this, the technical product is re-dissolved in hot water, decolorized with charcoal, and filtered at 170° F or higher. The filtrate is then cooled, with essentially pure monopentaerythritol crystallizing out. The crystals are separated by centrifuging and finally dried to yield the nitration-grade product of 99 percent purity. The liquor from the filtration is subsequently worked up for recovery of saleable dipentaerythritol.

Yields: The yield of total pentaerythritol is 80-85 percent, based on acetaldehyde charged.

Commercial Installations: This process or a modification is used by: Canadian Chemical Co., Ltd., Edmonton, Alta.; Commercial Solvents Corp., Agnew, Calif.; Delaware Chemicals, Inc., Staten Island, N. Y.; Hercules Powder Co., Louisiana, Mo.; Heyden-Newport Chemical Co., Fords, N. J. and Garfield, N. J.; Reichbold Chemicals Co., Tuscaloosa, Ala.; St. Maurice Chemicals Ltd., Varennes, Quebec; Trojan Powder Co., Allentown, Pa.

References: Petroleum Refiner, Nov.'56,pp173-179; *Ind. Eng. Chem.*, **50**, 1106-1114 (1958).



Peracetic Acid from Acetaldehyde—UNION CARBIDE CHEMICALS COMPANY

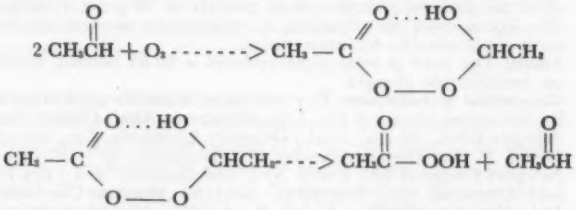
Application: A process for manufacturing peracetic acid, primarily for use in organic oxidation reactions.

Charge: Acetaldehyde, Oxygen (or air), Solvent. Esters and ketones are preferred solvents. Choice depends on the planned use for the peracetic acid.

Product: Peracetic acid is obtained from the process as a 20 to 35 percent solution in the chosen solvent. A small amount of acetic acid (less than 10 percent), formed as a by-product, may also be present. A sequestering agent such as sodium pyrophosphate is added to the product solution to inactivate any traces of heavy metal ions, which otherwise would lower the stability of the peracid by catalyzing its composition.

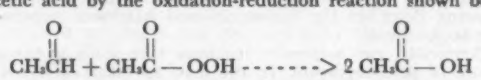
Pure peracetic acid has a melting point of 0° C and a boiling point of 110° C. It is customarily handled only in dilute solution, since in concentrated form it is subject to detonation by heat and shock.

Description: The process consists of two steps. Acetaldehyde is first oxidized below 0° C to acetaldehyde monoperacetate (AMP), an unstable peroxide which decomposes violently to acetic acid if allowed to warm up under ordinary conditions. The AMP is then decomposed either thermally or catalytically to peracetic acid and acetaldehyde. Equations for these two steps are given below.



The first reaction may be catalyzed by ozone, ultraviolet light, or heavy metal salts such as cobalt acetate. Ozone and ultraviolet light are preferred because metal ions, if not subsequently completely removed or deactivated, lower the stability of the peracetic acid.

The second reaction may be conducted either by non-catalytic pyrolysis or by heating the AMP solution in the presence of an acidic catalyst. In either case, continuous removal of acetaldehyde from the mixture is necessary to prevent its destroying the peracetic acid by the oxidation-reduction reaction shown below.

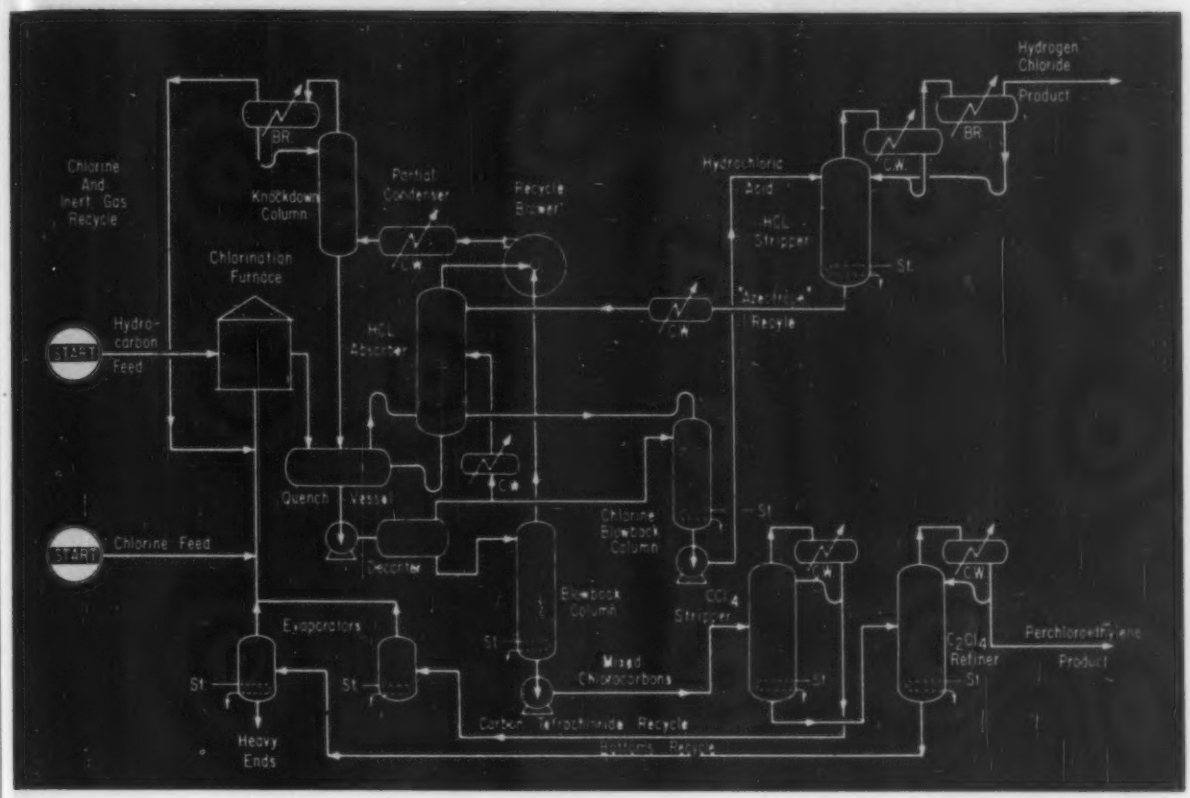


In one modification of the process, oxygen is first fed through an ozonator, in which approximately 3 percent of it is converted to ozone. This ozonated oxygen is then sparged into a 75 percent solution of acetaldehyde in acetone, contained in a tank reactor (Reactor No. 1) operated at a temperature of 0° C and a pressure of one atmosphere. Fresh acetaldehyde and acetone are continuously pumped into the reactor, and there is continuously withdrawn a solution containing 50 percent AMP by weight. Next, unreacted acetaldehyde is removed by distillation under reduced pressure, the solution being simultaneously diluted with additional acetone to avoid crystallization of AMP. The solution of AMP in acetone is then fed to the second reactor, in which the AMP is pyrolyzed at 100° C and a pressure of 200 mm. Hg absolute. Complete vaporization of the solution occurs under these conditions. The gases pass to the refining system, where fractionation is effected, giving acetaldehyde for recycle and a product solution containing 30 percent of peracetic acid, 64 percent of acetone, and 6 percent of acetic acid (formed as a by-product in the process).

Yield: Chemical yield of 80 percent theoretical, based on acetaldehyde consumed.

Commercial Installations: Union Carbide Chemicals Company is now constructing a large commercial unit at Institute, W. Va. It is scheduled for completion in 1959.

Reference: U.S. patent 2,804,473.



Perchloroethylene— SCIENTIFIC DESIGN COMPANY, INCORPORATED

Application: A process to produce perchloroethylene.

Charge: Oxygen-free chlorine and an inert-free hydrocarbon such as natural gas, LPG, or any mixture lighter than butane.

Products: The principal product is refined perchloroethylene, C_2Cl_4.

Description of Process: Chlorine, hydrocarbon, and several recycle streams are mixed and fed to the chlorination furnace. The chlorination process proceeds readily at high temperatures, sustained by the heat of reaction, without the aid of catalyst. From the furnace the reaction products go to a quench vessel where they are suddenly cooled.

The liquid quench mixture, consisting of carbon tetrachloride, perchloroethylene, and aqueous hydrochloric acid is decanted to separate acid from the chlorocarbons. Part of the acid is cooled and returned to the HCl absorber. The chlorocarbons are stripped in a blow-back column.

The mixed chlorocarbons from the stripping column are then fractionated first in a carbon tetrachloride stripper. The carbon tetrachloride overhead is recycled to the furnace. The remaining crude perchloroethylene is refined to yield high purity product, and the bottoms from the refining column are also recycled to the furnace.

Unquenched gases from the quench vessel pass to an HCl absorber where hydrogen chloride is absorbed in weak acid. The remaining gases from this absorption column are compressed by a recycle blower. Excess chlorine from the absorption system passes through a rectifying column. The excess chlorine overhead is recycled to the furnace.

The strong hydrochloric acid from the HCl absorber is also partially stripped to remove traces of dissolved chlorine and other contaminants which are returned to the HCl absorber. The purified hydrochloric acid is then sent to a conventional HCl stripping system, which yields anhydrous hydrogen chloride gas as the by-product of the process. Weak acid, close to the azeotropic composition, is recycled as scrubber liquor.

All equipment is of corrosion resistant alloy or nonmetallic material of construction. In particular, equipment which handles hydrogen chloride is fabricated with a ceramic lining or of impervious graphite. The chlorination furnace and the quench vessel pose extremely stringent problems in mechanical design, and involve some radically new techniques of fabrication.

Possible chemical reactions depend upon the hydrocarbon feedstocks. The following are examples:

(1) $2\ CH_4 + 6\ Cl_2 \rightarrow C_2Cl_4 + 8\ HCl$

(2) $2\ C_3H_8 + 10\ Cl_2 \rightarrow 2\ C_2Cl_4 + 12\ HCl$

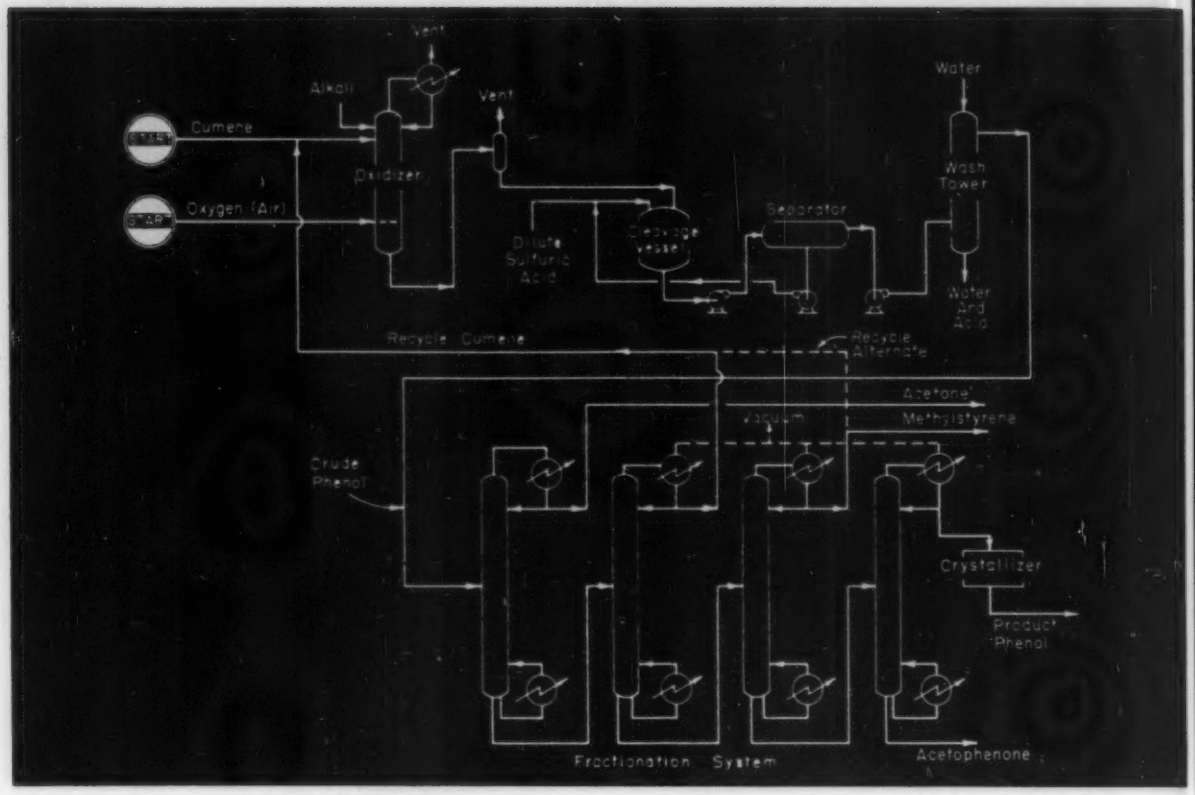
(3) $2\ C_3H_8 + 14\ Cl_2 \rightarrow 3\ C_2Cl_4 + 16\ HCl$

Operating Conditions: The chlorination furnace operates near atmospheric pressure at a temperature of 900-1200 F. The quench vessel, where rapid quenching is essential, operates at a low temperature. The absorption, stripping and fractionating columns operate at moderate temperatures and pressures.

Yields: The yield of products approaches 100% of theoretical. For example, one plant was designed to yield 20 pounds of perchloroethylene and 27 pounds of hydrogen chloride from 45 pounds of chlorine and 4 pounds of propane.

Commercial Installations: Pechiney Compagnie de Products. Chimiques et Electrométallurgiques, St. Auban, France.

Reference: PETROLEUM REFINER, Oct.,'54,p131. *Chemical Engineering*, May 5, 1958.



Phenol From Cumene

Application: A process for manufacturing synthetic phenol from cumene.

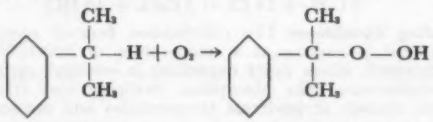
Charge: Cumene (isopropylbenzene), 99 percent purity; air; dilute sulfuric acid.

Products: Phenol (42.5°-43° C m.p.), acetone, α-methylstyrene, acetophenone.

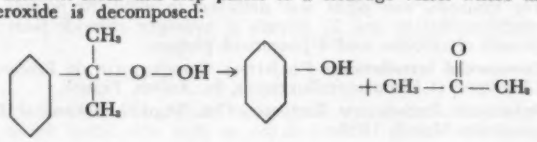
Description: The primary raw material for this process is cumene; methods for its manufacture are described elsewhere in this handbook. The cumene is treated to remove unsaturated and other materials likely to catalyze decomposition of peroxide during the oxidation step.

Oxidation is carried out in a special contactor designed for intimate mixing of gas and liquid. Air is passed countercurrent to cumene (fresh and recycle) to which an alkali such as sodium carbonate is added. Reactor contents are maintained at about 260° F, a pressure slightly above atmospheric, and a pH in the 8.5-10.5 range. Surfactants and other special additives are used to promote effective utilization of oxygen in the air. Vent gases from the contactor pass to a condenser where cumene and other organics are recovered. Special precautions are necessary in order to avoid explosive concentrations of peroxides.

In the oxidation step cumene hydroperoxide is produced according to the reaction:



Effluent from this step passes to a cleavage vessel where the peroxide is decomposed:



Cleavage to phenol and acetone is caused by the action of dilute sulfuric acid (10-25 percent); contacting takes place in an agitated vessel at about 130°-150° F. Decomposition is essentially complete. The reaction products form acid and oil layers which are separated; the acid layer is recycled to the cleavage vessel.

The oil layer is scrubbed with water in a packed tower, giving a crude phenol mixture as follows:

	Wt.-Percent
Acetone	8
Cumene	76
α-Methylstyrene	1
Phenol	14
Acetophenone	1

This mixture is separated in a series of conventional distillation columns. In the first colmn, acetone is removed and refined as required for sales. The second and third columns, operated under vacuum, separate cumene for recycle and methylstyrene for sales or recycle. If the latter material is recycled, it must be converted to cumene by a hydrogenation conveniently carried out in the presence of suspended Raney nickel catalyst.

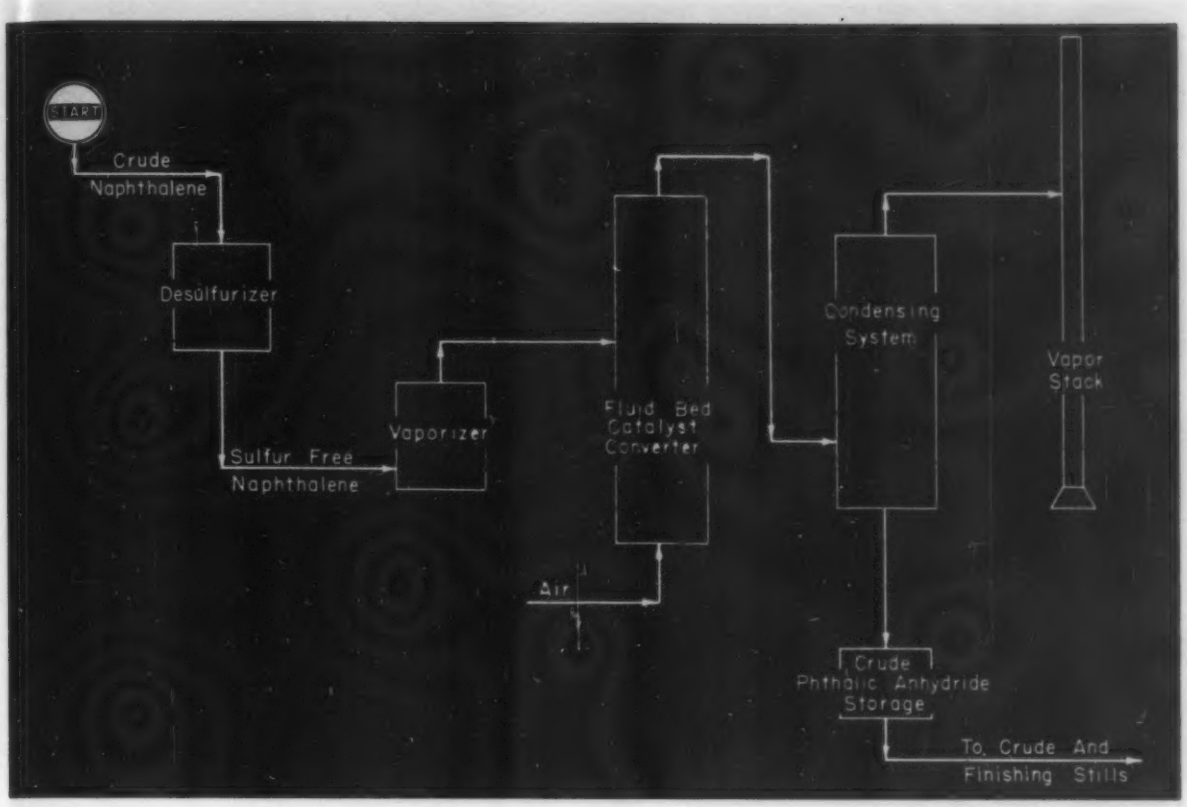
The final vacuum fractionator separates product phenol overhead which is further purified by crystallization. The bottom material from this column contains acetophenone in admixture with small amounts of phenol and tars. Further purification of this material may be required by customer specifications.

An important feature of the cumene phenol process is that substantial quantities of acetone are produced. The credit for this by-product strongly influences the competitive economics of this process for manufacturing phenol.

Operation Conditions: Given in the above text.

Yields: The over-all process yield, from raw material cumene to finished phenol, is about 93 percent of theory.

Commercial Installations: British American-Shawinigan, Ltd., Montreal East, Canada; Allied Chemical Corp., Frankfort, Pa.; Hercules Powder Co., Gibbstown, N. J.; Oronite Chemical Co., Richmond, Calif.; Shell Chemical Co., Houston (Deer Park), Texas.



Phthalic Anhydride— AMERICAN CYANAMID COMPANY

Application: A fluid catalytic process for manufacturing phthalic anhydride.

Charge: Desulfurized naphthalene.

Products: High purity phthalic anhydride.

Description: The fluid bed is essentially a reactor 70 feet high and 13 feet in diameter. It is designed with two zones; the reaction zone in the lower section, which is provided with a set of tubular heat exchangers for heating and cooling by a circulating heat medium liquid; and, above this zone is the quench zone, also provided with heat exchangers to cool the gases from the bed below reaction temperature. The two zones are separated by a baffle.

Preheated air enters at the base of the unit and naphthalene vapors are introduced above the bottom of the bed. The zone below the point of naphthalene entry serves as a regeneration zone.

Any catalyst carried past the baffle into the quench zone is disengaged and returned to the reaction zone through a center return vent. The quenched gases pass through stainless steel powered metal filters. They are then partially cooled and finally condensed in a heat exchanger type condenser in which the condensed product can be melted and pumped to storage for subsequent refining.

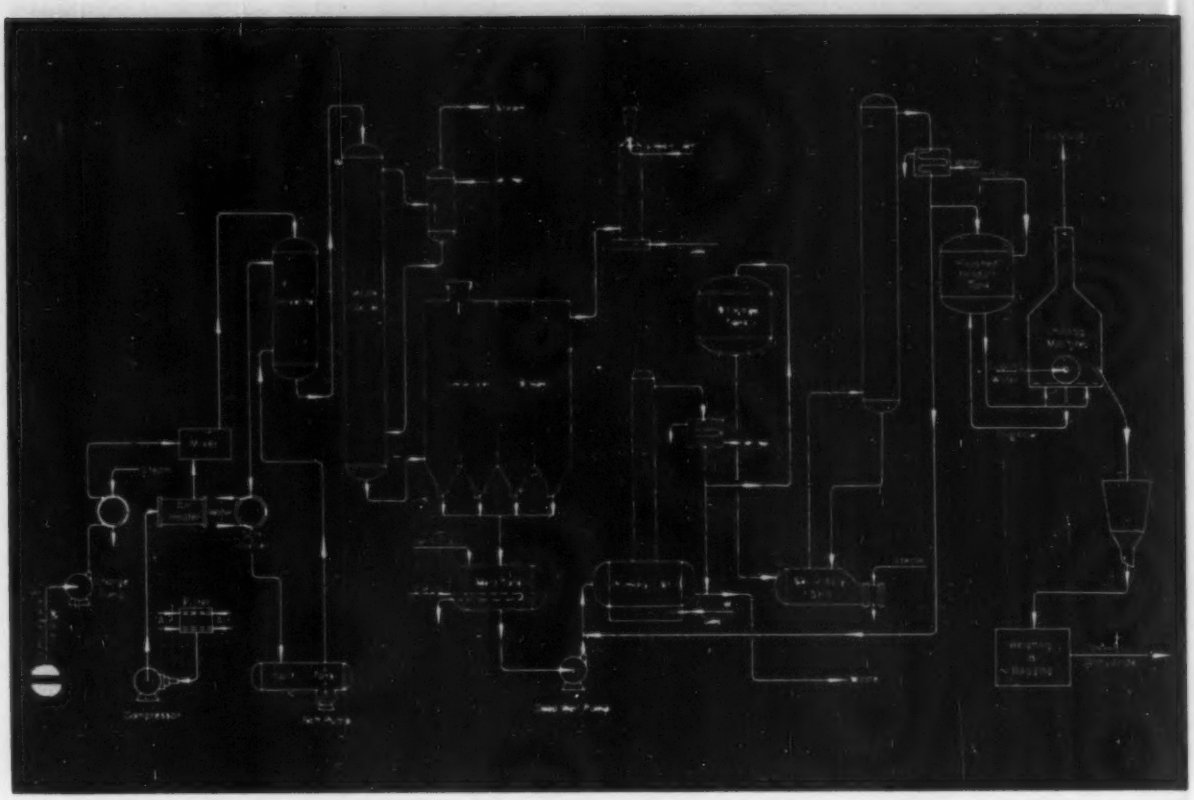
Several hundred thousand pounds of powdered catalyst, averaging 50-60 microns particle size, is charged into the unit. The essential catalyst component is vanadium pentoxide.

One big advantage of the fluid catalyst technique is the precise temperature control, within 1° or 2° C. Also the finely divided catalyst makes available an extremely large active catalyst surface running into working areas exceeding 10⁹ square meters for the entire catalyst charge. Consequently, the oxidation temperatures are much lower than those required in fixed bed units. These two factors —precise heat control and relatively low temperature— give a smoothly controlled reaction.

The process has the following major advantages over a fixed bed unit: 1. Extremely high output per dollar investment, 2. High degree of purity of converter product. Maleic anhydride content is low, and naphthaquinone is also low in comparison with the fixed bed operation. This means a simplified purification step with high recovery of chemically pure material and relatively low distillation residues, No lachrymatory tail gases, 4. Moderate labor requirements for large volume production, 5. Elimination of time consuming recatalyzation—discharging and reloading several thousand fixed bed converter tubes is a time-consuming and critical operation.

Commercial Installations: American Cyanamid Co., Bridgeville, Pa., 40,000,000 pounds per year.

References: PETROLEUM REFINER, March'53,p.113; April'53,p155; Oct.'53,p113.



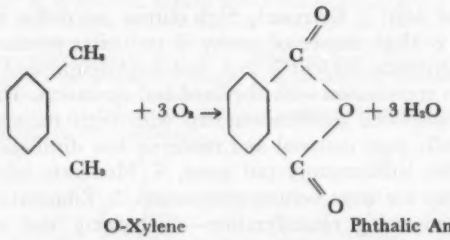
Phthalic Anhydride—CALIFORNIA RESEARCH CORPORATION

Application: This process is applied to the manufacture of phthalic anhydride.

Charge: The charge is ortho-xylene.

Product: The product is solid phthalic anhydride.

Description: The liquid ortho-xylene feed is pumped at controlled rates into vaporizers. The vaporized xylene is fed to a mixer where it is contacted with heated air. This mixture then goes to salt-cooled converter units where the following reaction occurs:



O-Xylene Phthalic Anhydride

This direct oxidation of the xylene to phthalic anhydride is promoted by the catalyst in the converter tubes which is based on vanadium pentoxide (V_2O_5). This catalyst must be carefully prepared for proper catalyst activity.

The reaction gases leaving the bottom of the converters are cooled to condense crude phthalic anhydride. The spent gases pass into catalytic incinerating furnaces to eliminate fume nuisance.

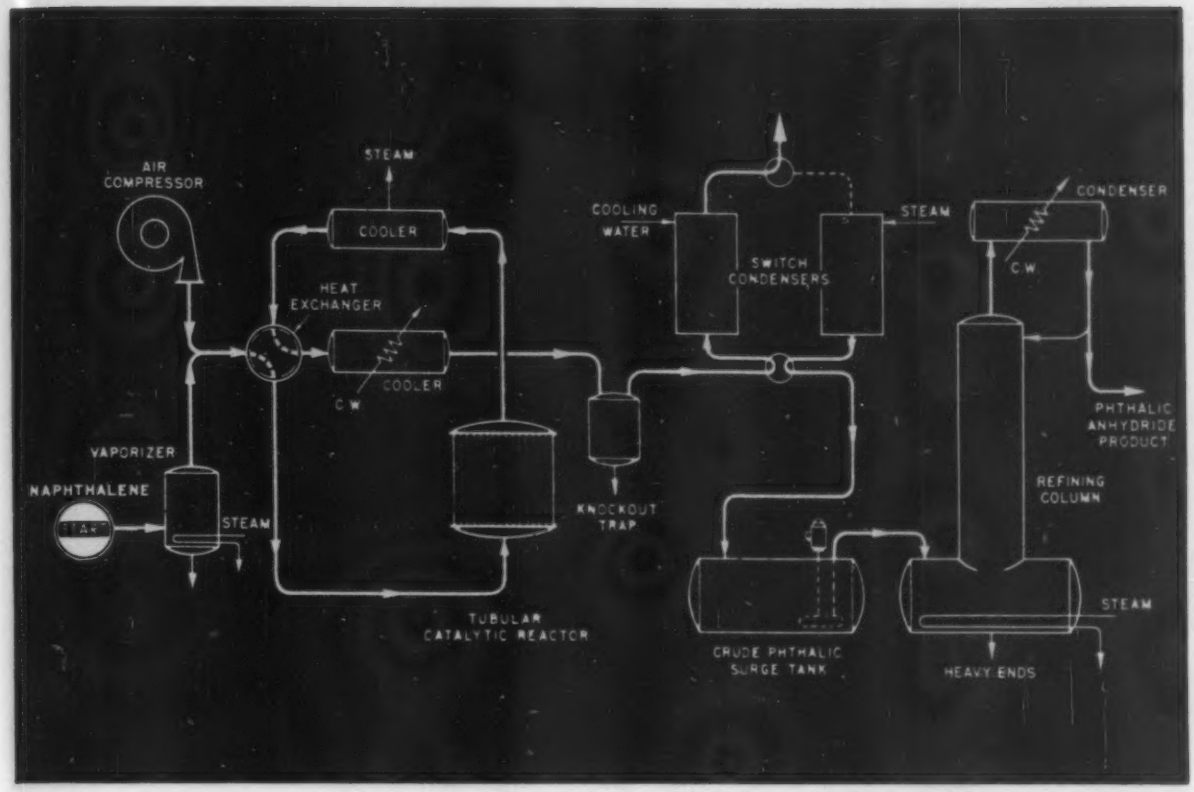
The crude phthalic anhydride goes to melt tanks for storage. The molten anhydride is distilled batchwise in two distillation stills in series. Light boilers such as benzoic acid are taken off under vacuum as a heads cut. The purified phthalic anhydride is removed as a heart cut from the second still which also operates under vacuum. The product goes from the secondary still to an aluminum storage tank. From this tank it is fed to a stainless-steel water-cooled surface for solidification. The final product in the form of chips is weighed and packed in paper bags. Molten anhydride also is shipped in steam-heated tank cars.

Operating Conditions: The most important operating conditions are the air/hydrocarbon ratio, the temperature in the converter and the contact time. Typical operating ranges for these variables are given below:

Air/Hydrocarbon Ratio	18-20
Temperature, F.	900-1150
Contact Time, Seconds	0.1-0.15

Commercial Installation: Oronite Chemical Company, Richmond, Calif.

Reference: PETROLEUM REFINER, Oct.'53,p113; *Chemical Engineering Progress*, Apr.'47,p167.



Phthalic Anhydride— SCIENTIFIC DESIGN COMPANY, INCORPORATED

Application: A process for the manufacture of phthalic anhydride.

Charge: Naphthalene and air.

Product: High purity phthalic anhydride.

Description: Phthalic anhydride is best produced from naphthalene in a fixed-bed catalytic vapor phase reaction. In sequence, molten naphthalene is vaporized, mixed with air, preheated by exchange with effluent gases, and fed to the reactor. The reactor cooling system (not shown) consists of molten salt circulating outside the tubes of the reactor.

Reaction effluent gases containing phthalic anhydride vapor are first cooled by a waste heat boiler generating steam, then used to preheat the feed mixture, and finally are cooled with cooling water to a temperature a few degrees above the dew point of phthalic anhydride. After leaving this cooler, the gases are passed through one of a pair of highly efficient switch condensers of novel design which condense solid crystals of phthalic anhydride. The condenser effluent gases, which may contain traces of by-products, are burned or water-scrubbed before release to the atmosphere. Meantime, in the alternate switch condenser, phthalic anhydride from the previous cycle is being melted out. The crude phthalic anhydride is treated to destroy contaminants and is then distilled under vacuum. The refined product may be flaked, pelletized, or packaged for shipment in liquid-full steel drums or tank cars.

Chemical reactions:

Main Reaction—

$$C_{10}H_8 + 4\tfrac{1}{2}\,O_2\,(air) \rightarrow C_8H_4O_3 + 2\,CO_2 + 2\,H_2O$$

Principal Side Reaction—

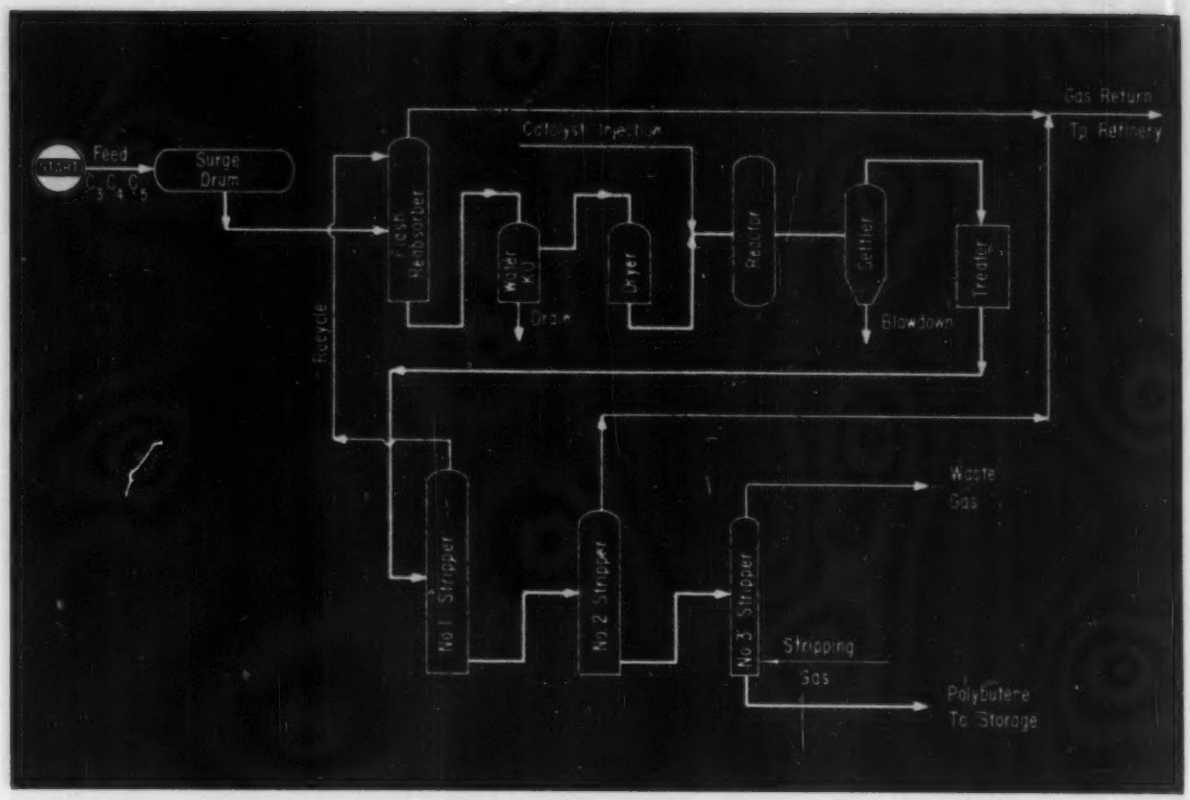
$$C_{10}H_8 + 12\,O_2\,(air) \rightarrow 10\,CO_2 + 4\,H_2O$$

Minor Side Reaction—

$$C_{10}H_8 + 9\,O_2\,(air) \rightarrow C_4H_2O_3\,\left(\begin{matrix}\text{Maleic}\\ \text{Anhydride}\end{matrix}\right) + 6\,CO_2 + 3\,H_2O$$

Note that almost all side reactions are much more exothermic than the desired main reaction. SD's highly selective oxidation catalyst thus aids temperature control and permits higher throughput rates in the reactor.

Commercial Installations: Witco Chemical Company, Chicago; (under construction): (1) Staatsmijnen in Limburg, Geleen, Holland; (2) A European plant, name withheld.



Polybutene— COSDEN PETROLEUM CORPORATION

Application: Processes for manufacturing liquid polybutene (polyisobutylene).

Charge: Refinery gas stream from catalytic and thermal cracking, including C_3's, C_4's and C_5's.

Product: Clear, viscous liquid polybutene from 500 to 1500 molecular weight and from 100 to 20,000 SSU viscosity.

Description: Polybutenes are polymerized butylenes of varying molecular weight and viscosity.

Raw material for the process consists of light hydrocarbons from refinery cracking plants and consisting primarily of the butane-butylene fractions, but including small quantities of materials in the C_3 and C_5 ranges.

The reactor feed is a combination of fresh feed and butylene recycle. This feed is first dried and then precooled with reactor effluent. Immediately before entering the reactor a slurry of anhydrous $AlCl_3$ and light polymer is injected, along with gaseous HCl activator, into the feed stream.

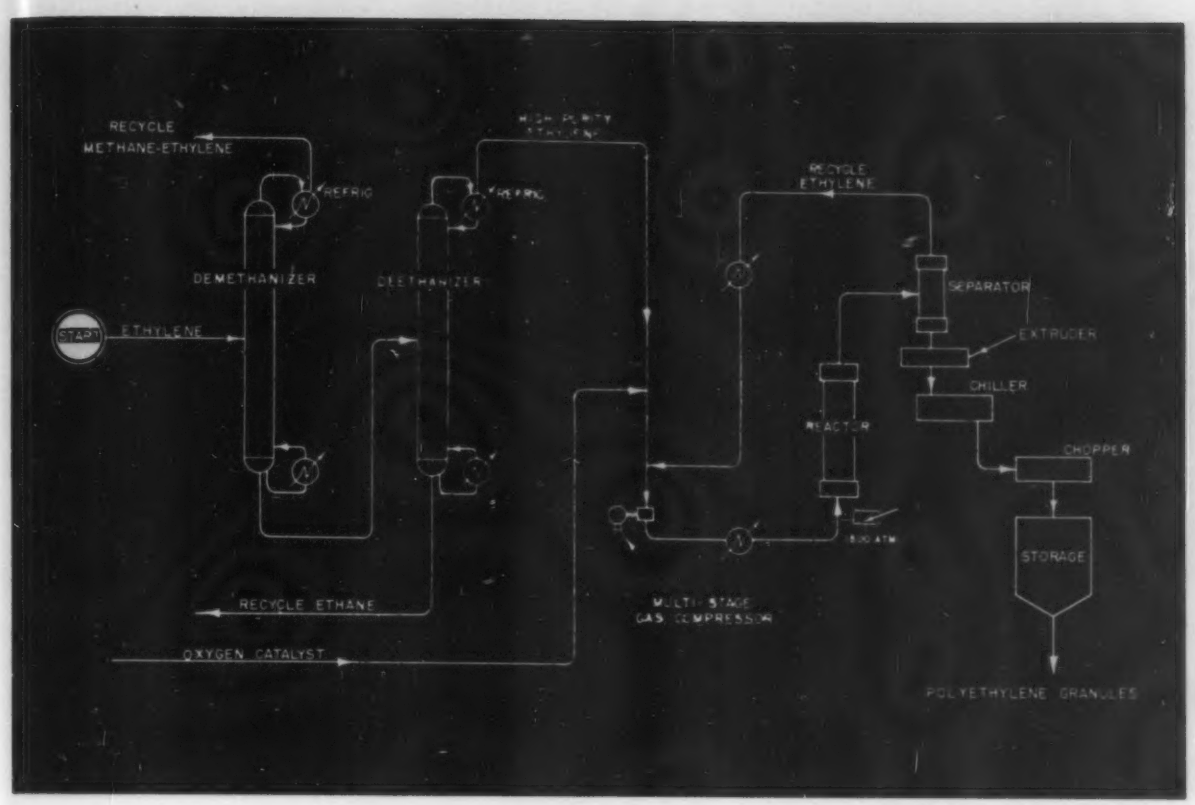
The exothermic polymerization reaction begins to take place immediately and heat is removed by an ammonia-cooled refrigeration bundle.

Temperature is a major control for viscosity and molecular weight, with high molecular weight polymers forming at low temperatures and decreasing molecular weights as the temperature is increased.

Effluent from the reactor enters a settler to concentrate the suspended catalyst and return it to the reactor. Spent catalyst is removed by periodic blowdown. The decanted effluent is treated to remove contaminants; then it is fractionated and stripped to recover the polybutene as a clear, viscous liquid with the physical qualities determined by the reactor conditions. Unreacted butylenes are recycled to the reactor feed from the purification section and excess light and heavy hydrocarbon fractions are returned to the refinery for further use.

Polybutene has a number of important industrial applications among which are: the manufacture of calking and sealing compounds, adhesives, vibration dampeners, surgical tapes, electrical insulations, and special lubricants.

Commercial Installations: Amoco Chemicals Corporation, Wood River, Ill., El Dorado, Ark., Yorktown, Va.; Cosden Petroleum Corp., Big Spring, Texas; and Oronite Chemical Co., Richmond, Calif.



Polyethylene (High Pressure-ICI)

Application: A process for the continuous manufacture of polyethylene.

Charge: Ethylene gas of 90-95 percent purity.

Product: Solid polyethylene.

Description: Polyethylene manufacture requires high purity ethylene and the first step is to purify the ethylene plant product.

The first purification column is the demethanizer in which the overhead, consisting of methane-ethylene, is taken back to the ethylene plant and the bottoms to the second tower where 99.8-99.9 percent ethylene is taken overhead with the bottoms going back to the ethylene plant.

In the *mass polymerization* process, an operating pressure of about 1500 atmospheres and a temperature of about 375° F is used. A free radical yielding catalyst, such as oxygen, is added to the feed and the compressed mixture is fed to the reactor. Once initiated the reaction proceeds quite rapidly with about 25 percent of the ethylene being converted to high molecular weight polymer. Special means are provided to maintain essential isothermal conditions of 375° F.

The effluent from the reactor passes to a separator vessel in which unconverted ethylene is removed and recycled to an intermediate stage of the charge gas compressor. This ethylene contains no oxygen which, though serving as catalyst or initiator, is consumed in the reaction.

The liquid from the separator is water-white polyethylene with a very high viscosity. It is extruded in a form which can be quickly chilled and solidified, such as a continuous ribbon. Final steps in the process are chopping, bin storage, sacking and shipping.

In the *water-solvent polymerization* process, an operating pressure of about 1,000 atmospheres is used. An aromatic hydrocarbon is added as a solvent to improve polymer solubility in the reaction zone and thus permit easier and quicker removal of the formed polymer before it is attacked by growing polymer chains. A mixture of fresh and recycle ethylene, plus about 20 ppm oxygen catalyst, is dissolved in a benzene-water mixture at 375° F. The major constituents in the charge have a weight ratio of about 1.0:1.0:1.5 ethylene:benzene:water. The water contains 100 ppm of oxygen. The charge is fed to a stainless-steel tubular reactor and during the course of reaction additional water is injected to maintain a more constant catalyst concentration throughout the reactor. About 17 percent of the ethylene is converted to polymer. Isothermal conditions of 375° F are maintained. The effluent from the reactor passes to a separator where the unconverted ethylene is removed and recycled as in the mass process. The liquid, consisting of polymer, benzene, and water is sent to a distillation unit where benzene and water are ultimately separated from the heavier polymer.

In the water-solvent process, water carrying additional initiator is injected at multiple points along the reaction tube in order to attain a higher conversion of the ethylene per pass through the reactor. The "half-life" of these initiators normally used is low and consequently it is necessary to continually add initiator to maintain the rate of polymer formation.

The separated polymer is handled as described above for mass-polymerized ethylene.

The product polymer has a molecular weight of 18,000-30,000.

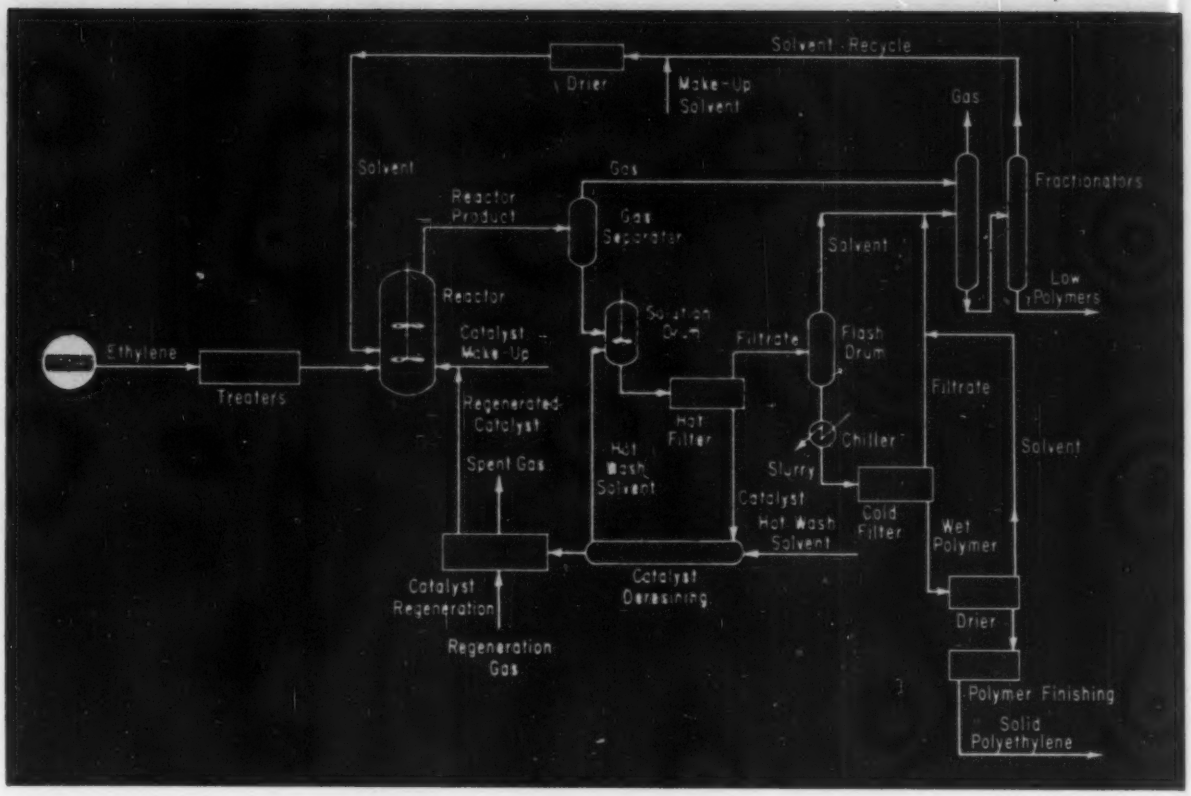
The typical processes described above are subject to variations imposed by the particular properties of polymer desired and the research findings of individual producers. Operating pressures range from 1,000 to 2,000 atmospheres. Autoclave reactors may be used. Free radial generating catalysts which may be used, in addition to oxygen, would include organic peroxides such as benzoyl peroxides and di-tertiary butyl peroxide. Azo compounds and metal alkyls are also effective.

Operating Conditions: Typical values are given above.

Yields: Over-all yield from ethylene is about 95 percent.

Commercial Installations: Union Carbide Chemicals Company, Charleston, W. Va.; Texas City, Texas; Seadrift, Texas; Torrance, Calif., Whiting, Ind. E. I. du Pont de Nemours & Company, Orange, Texas. Canadian Industries, Ltd., Edmonton, Canada. Spencer Chemical Company, Orange, Texas. The Dow Chemical Company, Freeport, Texas. Texas Eastman Company, Longview, Texas. Monsanto Chemical Company, Texas City, Texas. U. S. Industrial Chemicals Co., Tuscola, Ill., Pasadena, Texas, and Koppers Co., Inc., Port Arthur, Texas.

Reference: "The Chemistry of Petrochemical Reactions," Lewis F. Hatch. "Polythene," A. Renfrew and Phillip Morgan. Chem. Eng. News, June 22, 1959, p72.



Polyethylene (Low Pressure-Slurry-Solution Process)

Application: A relatively low-pressure process for the continuous production of polyethylene.

Charge: Ethylene gas of 99 percent purity.

Product: Solid polyethylene.

Description: This is a process in which solid catalyst and a solvent are present in the reactor as a slurry, and the polymer is maintained in solution until after the catalyst is removed from the reaction mixture.

The ethylene charge gas, free of sulfur compounds, is treated for removal of catalyst poisons such as water, oxygen and carbon dioxide. Conventional treating may be employed, such as hot metallic copper for oxygen, anhydrous calcium sulfate or alumina for water and supported caustic for carbon dioxide.

The treated ethylene and a suitable hydrocarbon solvent are charged to the reactor at rates to give the equivalent of around 5 weight percent ethylene. A suitable catalyst, such as hexavalent chromium oxide (Cr_2O_3) on a silica-alumina support, is maintained at a concentration of 0.5 percent or less (based on weight of solvent). The solvent may be a C_5 to C_8 paraffin, a naphthene or an aromatic such as toluene or xylene. The aromatics have higher solvency toward polyethylene than the other solvents. The solvent serves several functions in addition to its role as a solvent for ethylene and polyethylene. It protects the growing polymer chain from chain-breakers, controls the viscosity of the solution, controls the rate of ethylene consumption to promote good polymer growth, and it serves as a medium for dissipating the heat of reaction. The reactor is maintained at a temperature of 200° to 300° F and a pressure in the range of 100 to 500 psig.

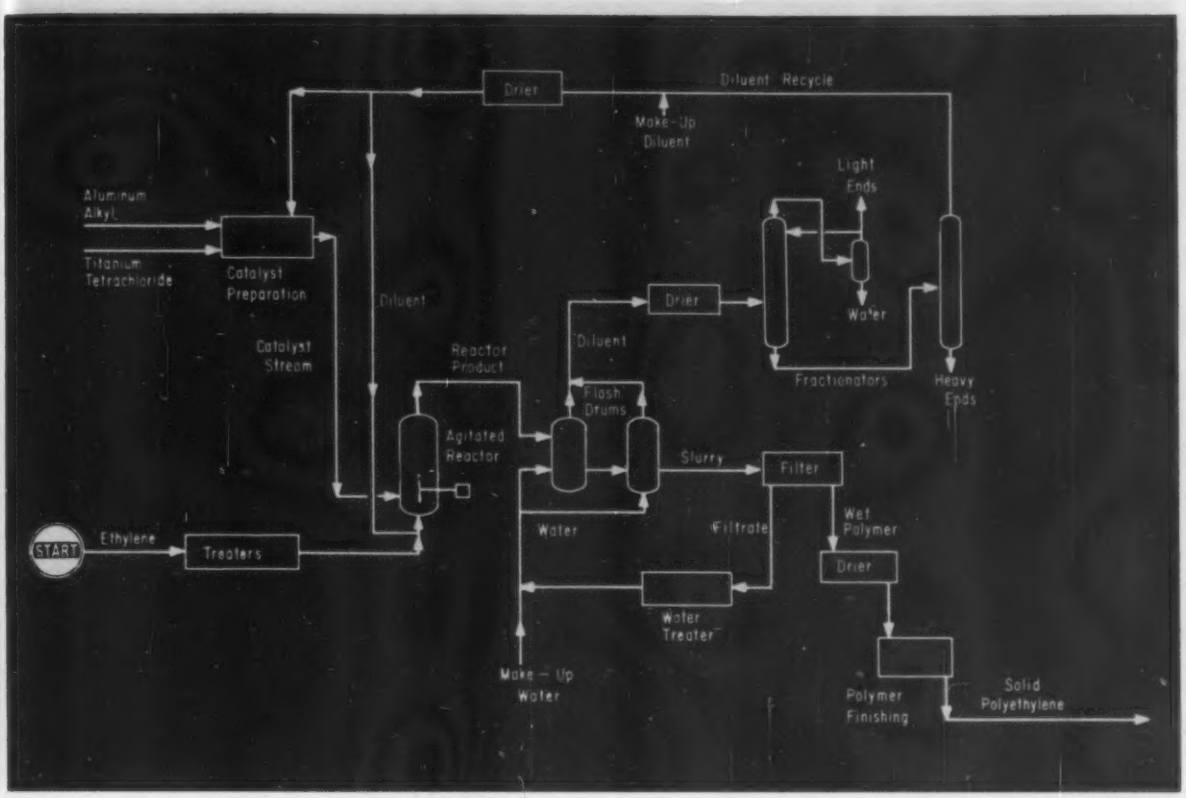
The reactor product is sent to a gas separator and then to a solution drum where additional hot solvent from the deresining operation is added to insure that all of the polymer is in solution. The mixture is then filtered to remove the catalyst which is sent to a deresining chamber where residual polyethylene is recovered from the catalyst. The spent catalyst is regenerated and returned to the reactor.

The hot filtrate is sent to a flash drum for removal of some of the solvent and then to a chiller where the temperature is reduced to 75° to 150° F. The increased polymer concentration and temperature reduction causes the high molecular weight polymer to precipitate and form a slurry. Anti-solvents, such as propane, alcohols or water are usually employed at this step to facilitate separation of the polymer from the solvent. The slurry is filtered to recover an essentially ash-free polymer which is dried and finished as polyethylene pellets. The filtrate and flashed solvent streams are combined and sent to fractionators, along with the separator gas, for solvent recovery and purge of inert gas and low polymers. The solvent is combined with make-up solvent, dried and sent to the reactor.

Operating Conditions: The ranges of the principal operating conditions are given in the foregoing description. They are influenced by the properties of the solvent employed.

Yields: The conversion of ethylene to polymer is virtually 100 percent, and recovery of solid polymer is in excess of 98 percent.

Commercial Installations: The following plants utilize variations of the process principles described here: Celanese Corp. of America, Pasadena, Texas; W. R. Grace and Co., Baton Rouge, La.; Phillips Chemical Co., Pasadena, Texas, and Union Carbide Chemicals Co., Seadrift, Texas.



Polyethylene and Polypropylene (Low Pressure-Ziegler)

Application: A low pressure process for the continuous production of polyethylene (or polypropylene).

Charge: Ethylene gas of 99 percent purity for polyethylene. (Propylene of similar purity for polypropylene.)

Product: Solid polyethylene (or polypropylene).

Description: The accompanying flowsheet describes the principles of the low pressure polyethylene process that employs Ziegler catalysts. Many details of the process are still confidential, especially those related to catalyst preparation and to catalyst and ash removal after the polymer is formed. Numerous catalyst combinations are possible; however, the popular combination consists of aluminum triethyl, which promotes the polymerization, and titanium tetrachloride, which in combination with aluminum triethyl forms a finely divided precipitate which catalyzes the anionic polymerization. The catalyst constituents are extremely reactive to water and oxygen; therefore, since only a trace of catalyst is required, it is carried in a carefully dried diluent under conditions that make it safe to handle.

The ethylene charge gas is treated for removal of sulfur compounds, oxygen, water and carbon dioxide, and is then charged to the reactor. The diluent may be a C_5 to C_7 paraffin or naphthene or one of the lower aromatics. The catalyst is charged as a very dilute stream. The reactor is maintained at a pressure in the range of one atmosphere to 100 psig and a temperature of 140° to 170° F.

The reactor product is sent to a series of flash drums to remove the diluent. These drums are maintained at conditions in the range of 3 to 5 psig and the appropriate temperature to flash the diluent. Water is added to the flash drums to destroy the catalyst and slurry the polymer. The diluent is sent to a drier to remove entrained water and then charged to a fractionator where light ends and water are removed as an azetrope. The bottoms is sent to a second fractionator for removal of heavy ends, and the diluent is recovered for recycle.

The water-polyethylene slurry is filtered, and the aqueous filtrate is treated and recycled to the flash drums. Alcohol may be used in place of water to destroy the catalyst and wash it from the polymer. Additional filtration steps and special treating agents may be employed to help remove the catalyst. The solid polyethylene is dried, extruded and finished to form polyethylene pellets. Higher boiling diluents may be used. In this case a different diluent recovery system would be required.

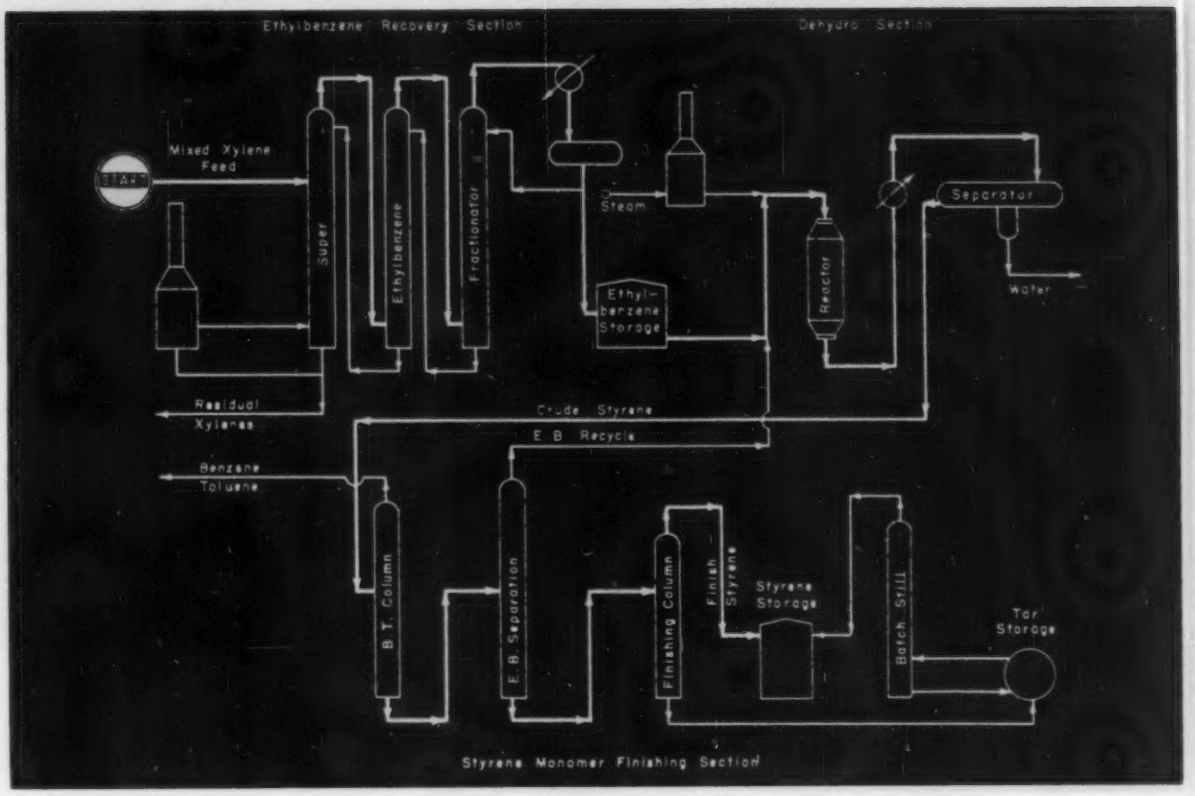
Operating Conditions: The operating conditions given above are influenced by the physical properties of the diluent.

Yields: The over-all yield of polymer is around 95-98 percent of the ethylene consumed.

Polypropylene: This polymer is made from propylene in essentially the same process and under nearly the same conditions except that titanium trichloride is used in place of titanium tetrachloride. This increases the yield of polymer to over 90 percent based on the olefin charged.

Commercial Installations: *Ziegler Polyethylene:* Dow Chemical Co., Bay City, Mich.; Hercules Powder Co., Parlin, N. J.; Koppers Chemical Co., Port Reading, N. J.; and Union Carbide Chemicals Co., Institute, W. Va.

Polypropylene: Avisun Corp., Port Reading, N. J. and Hercules Powder Co., Parlin, N. J.



Styrene— COSDEN PETROLEUM CORPORATION

Application: Process for manufacturing styrene monomer by recovery of ethylbenzene in petroleum stocks.

Charge: Mixed xylenes from aromatic purification unit.

Product: Plastic or rubber grade styrene monomer.

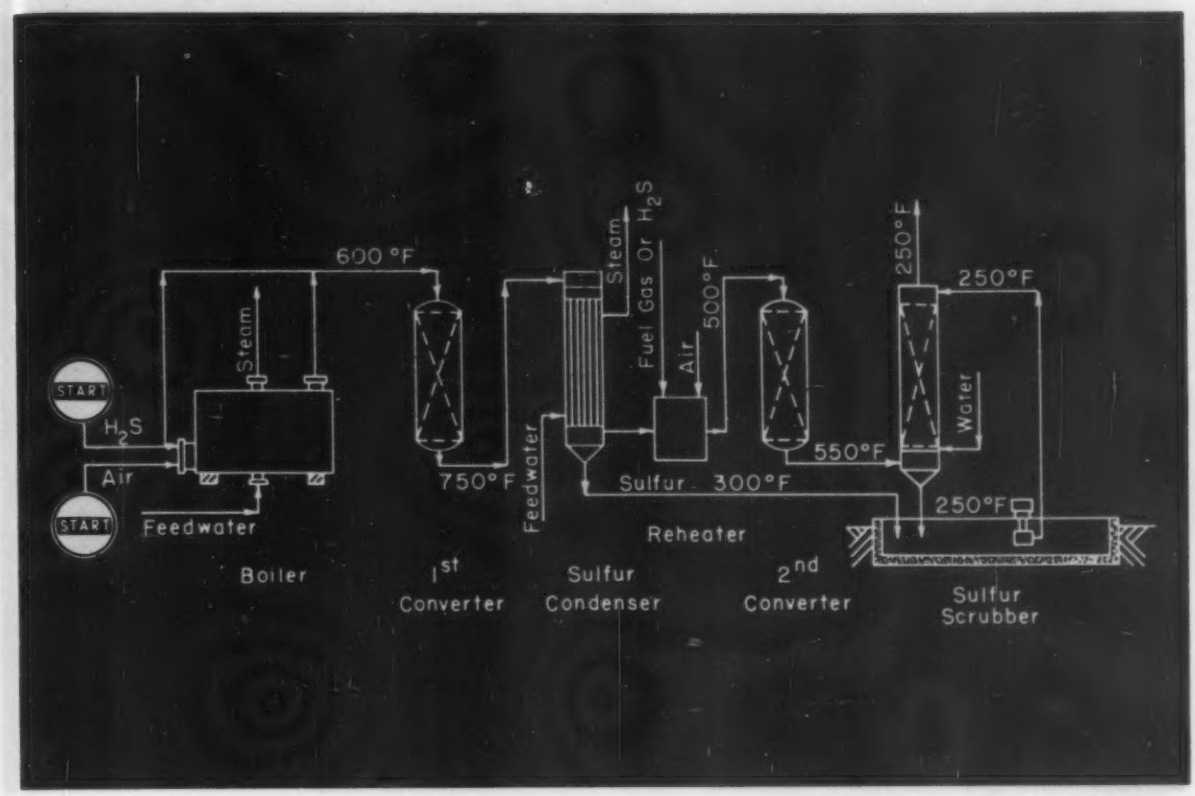
Color	10 Max.	(APHA)
Assay		99.6% Min.
Polymer		Nil
Sulfur		0.003% Max.
Aldehydes		0.02% Max.
Peroxides		0.01% Max.

Description: The feed stock to the super fractionating column is mixed xylene isomers containing essentially no non-aromatic hydrocarbons boiling in the xylene range. In this column, ethylbenzene which boils at 3.9° F lower than its nearest xylene isomer, (paraxylene), is separated in sufficient purity to make at least 99.6 percent styrene monomer. To affect this separation, three 200-foot columns are used in series and operated at high reflux rates. The ethylbenzene product from the recovery section has to be maintained essentially free from any other hydrocarbons boiling in the range of ethylbenzene and styrene monomer as purity produced here will govern the maximum purity of finished styrene monomer.

Fresh ethylbenzene is combined with recycle and charged to the dehydrogenation reactor after mixing with super heated steam. The dehydrogenation takes place at low pressure and a high mole ratio of steam to ethylbenzene is maintained. The reactor effluent is condensed and collected in a separator where the steam condensate is withdrawn. Reactor pressure and temperature are major control points for maintaining conversion in the optimum range of 35 to 40 percent per pass. Ethylbenzene conversion to styrene monomer will approximate 90 weight percent.

In the styrene monomer finishing section, the small amount of benzene and toluene produced by cracking in the reactor is first removed by fractionation in a small vacuum column. In the next column, ethylbenzene, for recycle back to the reactor, is separated from the styrene. This separation is accomplished in one column operating at an extremely low pressure. This effects substantial savings in investment and operating cost over the conventional two-column system. Inhibitors are added and high temperatures avoided in order to minimize polymer formation. Another small column is required to separate the finished styrene monomer from small amounts of tar and polymer formed during the operation. The tars and polymers are collected in a batch pot and periodically the remaining monomer in this material is recovered.

Very high recovery of ethylbenzene is realized by this process. It avoids the corrosion and purification problems associated with aluminum chloride alkylation of benzene and ethylene. Furthermore, no impurities of the type normally found in synthetic ethylbenzene are present which produce unstable monomers that complicate styrene monomer recovery and finishing operations. The entire unit is essentially free of corrosion and fouling problems and can be operated for long periods without downtime.



Sulfur Recovery— GIRDLER CONSTRUCTION DIV., CHEMETRON CORP.

Application: The process is applied to the recovery of elemental sulfur from hydrogen-sulfide bearing gases.

Charge: Although the acid gas stream from a Girbotol plant is an ideal feed material, almost any hydrogen sulfide or hydrogen sulfide and carbon dioxide gas mixture may be employed.

Product: The quality of the sulfur is equal to or better than bright Gulf Coast sulfur.

Description: The process is based on a modification of the original Claus process for carrying out the highly exothermic reaction:

$$H_2S + 1/2O_2 \rightarrow S + H_2O$$

In order to remove the heat generated more efficiently and maintain better control over the process the above reaction is carried out in two steps as follows:

(1) $H_2S + 3/2O_2 \rightarrow SO_2 + H_2O$

(2) $2H_2S + SO_2 \rightarrow 3S + 2H_2O$

The accompanying flow plan is typical of a two stage plant and shows the approximate temperatures for a feed gas containing about 90 percent hydrogen sulfide. Reaction (1) takes place in the combustion chamber of a fire-tube boiler where approximately one-third of the hydrogen sulfide is burned to sulfur dioxide.

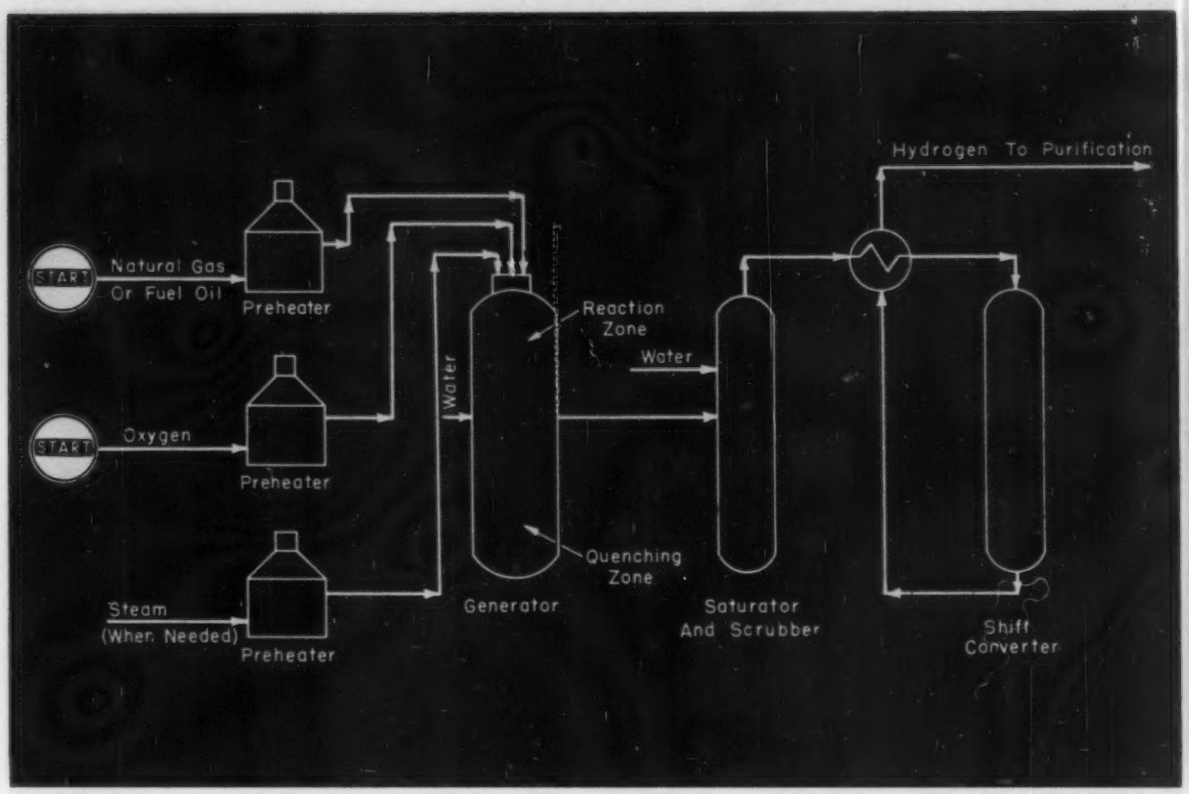
Following the steam boiler the gases pass through the first converter where most of reaction (2) takes place and a gas temperature rise results. It is estimated that 70-80 percent of the sulfur recovered is formed in the first stage and the balance in the second after intermediate product removal. The catalyst employed is activated bauxite which has an indefinite life, being subject only to mechanical failure.

In order to remove the sulfur formed in the first converter the gases are cooled to approximately 300° F and the sulfur condensed. The gases are reheated before entering the second converter. Final cooling and condensation after the second converter takes place in a carbon steel, Raschig ring packed scrubber where the hot gases pass countercurrent to liquid sulfur. The circulating sulfur, heated in the scrubber, returns to the sulfur tank carrying with it the newly formed sulfur. The tail gases largely consist of nitrogen, water vapor, carbon dioxide (if present originally), and small percentages of unreacted hydrogen sulfide and sulfur dioxide.

Yields: Generally a minimum of 90 percent of the sulfur present in the hydrogen sulfide may be recovered in a two-stage plant, and up to 95 percent recovery is readily attained in commercial practice. However, a single-stage plant, designed to recover 80-85 percent of the hydrogen sulfide as sulfur, may prove more economical for smaller capacity installations.

Commercial Installations: Companies using this process are: Freeport Sulfur Co., Stanolind Oil and Gas Co., Standard Oil Co., (New Jersey), Union Oil Co., General Chemical Division of Allied Chemical Co. and Idemitsa Kosan Co., Ltd.

Reference: *Petroleum Processing*, Sept.'54,p1404.



Synthesis Gas— HYDROCARBON RESEARCH, INC.—TEXACO DEVELOPMENT CORP.

Application: A process for producing synthesis gas for use in the manufacture of ammonia, methanol or hydrogen at required purities.

Charge: The process may use almost any liquid or gaseous hydrocarbon charge stock.

Product: A gaseous mixture comprised principally of hydrogen and carbon monoxide, with smaller amounts of carbon dioxide, water and methane.

Description: The process involves the oxidation of a hydrocarbon feed stock in the presence of a controlled quantity of oxygen. The process achieves substantially complete conversion of the feed materials.

When CH_4 is used as the feed material, two of the principal reactions involved are:

(1) $$CH_4 + 2\,O_2 \rightarrow CO_2 + 2H_2O$$

(2) $$CH_4 + \tfrac{1}{2}\,O_2 \rightarrow CO + 2H_2$$

Similar reactions may be written for other hydrocarbons.

The composition of the gas leaving the combustion zone tends to aproach that corresponding to the equilibrium at reaction temperature, for the "water gas shift" reaction.

(3) $$CO + H_2O = CO_2 + H_2$$

For the partial oxidation of gaseous fuel the process is as follows: The feed gas is compressed, if necessary, and preheated. Oxygen and the feed gas then enter the burner of the generator in which the reactions occur. When high purity hydrogen is the intermediate or ultimate product, the generated gas, on leaving the combustion zone at a temperature of over 2,000° F, is quenched by water and then enters the saturator scrubber in which it is washed by countercurrent contact with water. The hot generator effluent produces steam by direct contact with quench water so that the gas leaving the top of the saturator-scrubber carries steam, all of which is needed to complete the shift reaction economically.

The saturated gas stream is next preheated by exchange against shift converter effluent and then passed over a suitable catalyst in the shift converter. Here, most of the CO is oxidized to CO_2 with one mol of H_2 being released for each mol of CO so oxidized.

Further purification of the shift converter effluent may be accomplished by any one of several available processes or a combination of such processes, the choice depending in part on the end use of the synthesis gas.

When the raw material is liquid fuel, the feed materials are the fuel oil, the oxygen and water condensate—the three being in proper ratios to control temperature, methane content and carbon content in the gas produced. The condensate is pumped, preheated and vaporized before entering the generator. From this point on, the process is similar to that for the partial oxidation of gaseous fuel.

Burners of proper design may be provided for a given installation so that the same generator may be operated on either gaseous or liquid feed. A change from liquid to gaseous fuel, or vice versa, can be provided for by the installation of the appropriate burner.

Usual Operating Conditions:

Temperature	over 2,000° F
Pressure	250-500 psig

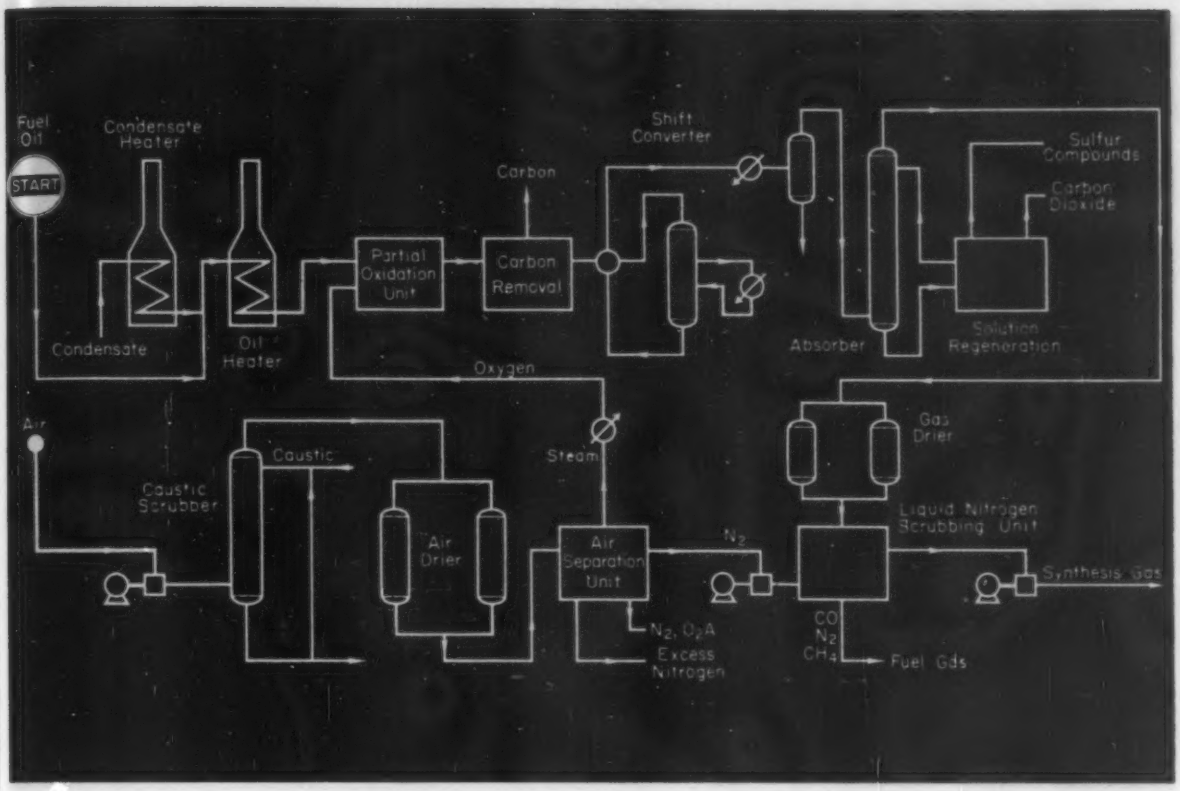
Yields: Yields are expressed in terms of (H_2 + CO) make per unit feed material. Yields are a function of feed material composition and degree of preheat. Typical yields are shown below:

SCF (H_2 + CO)/SCF Feed Gas	2.79	—
SCF (H_2 + CO/BBL Liquid Feed	—	15,800

Oxygen Requirement:

SCF (H_2 + CO)/SCF O_2	3.90 when using natural gas 3.92 when gasifying heavy fuel oil
Ratio H_2 to CO	1.72 when using natural gas 0.97 when gasifying heavy fuel oil

Commercial Installations: Total licensed capacity amounts to nearly half a billion SCFD per day of (H_2 + CO).



Synthesis Gas (Fuel Oil)—THE FLUOR CORPORATION, LTD.

Application: A process for the manufacture of nitrogen hydrogen mixture or hydrogen.

Charge: Air and fuel oil.

Product: Hydrogen or synthesis gas containing 75 percent hydrogen and 25 percent nitrogen.

Description: Briefly, the process indicated consists of the following steps: (1) Separation of air into nitrogen and oxygen; (2) controlled partial oxidation of fuel oil to produce hydrogen; (3) purification of the hydrogen to remove unconverted carbon, sulfur compounds, carbon dioxide, and carbon monoxide. If snythesis gas is desired, methane, argon, and residual carbon monoxide are removed in a nitrogen scrubbing unit.

As indicated in the simplified flow diagram, air is compressed, scrubbed with caustic to remove carbon dioxide, dried, and separated in a low temperature air separation unit (A.S.U.) into nitrogen of 99.99 percent purity, oxygen of 85 percent or better purity, and a stream containing nitrogen, oxygen, and argon. When producing sufficient oxygen for the partial oxidation reaction, excess pure nitrogen will be produced over that required for ammonia. A controlled quantity of oxygen is fed with preheated oil-steam mixture to the partial oxidation unit, where a series of reactions take place yielding hydrogen, carbon monoxide and small quantities of carbon dioxide and methane. After removal of traces of unconverted carbon, the gas is fed to a shift converter, where the carbon monoxide reacts with steam to form carbon dioxide and water. The effluent is cooled in a series of heat exchangers and coolers and fed into a contactor for removal of carbon dioxide. For this step, monoethanolamine, hot potassium carbonate, Giammarco-Vetrocoke, or other suitable processes may be used.

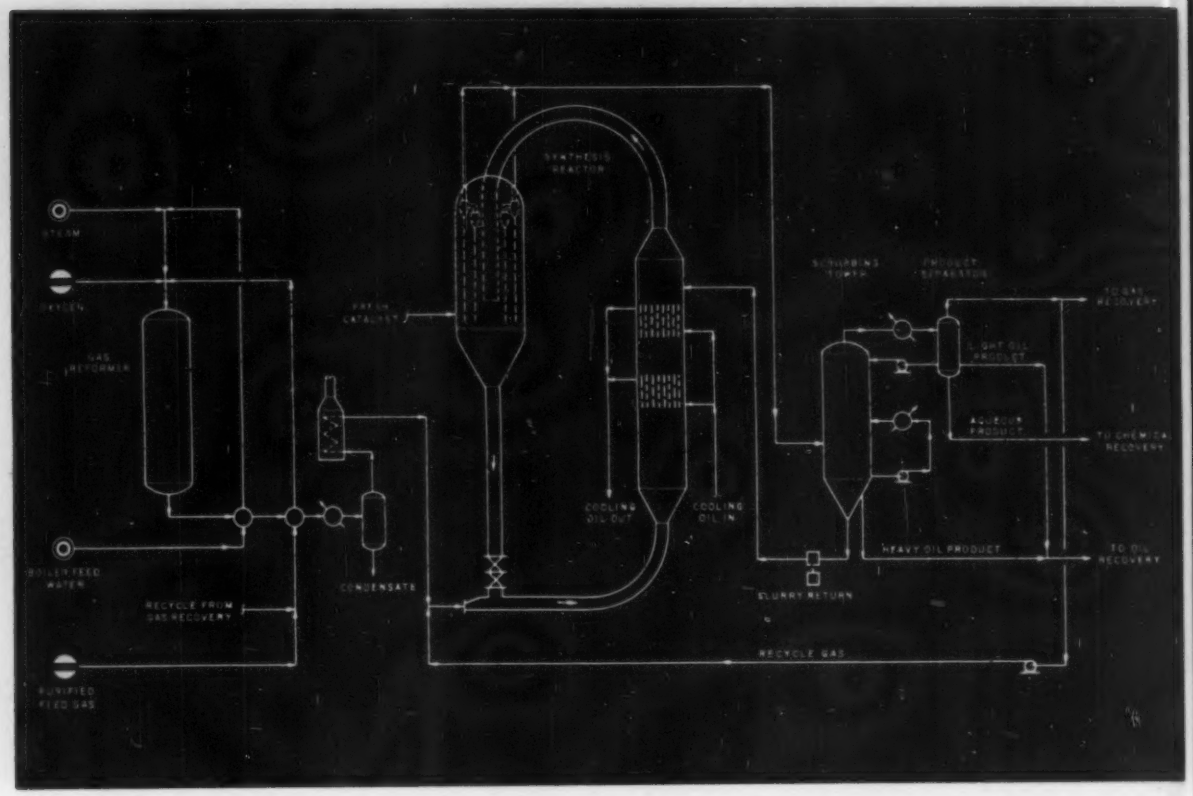
The hydrogen containing traces of carbon dioxide, argon, carbon monoxide, and some methane is then dehydrated and fed into a low temperature nitrogen scrubbing unit (N.S.U.) where these remaining impurities are scrubbed out the bottom as a low Btu value fuel gas (350-500 Btu/CF). The gas leaving the top of the tower contains about 80 percent hydrogen and is easily adjusted to 75 percent hydrogen by introduction of a controlled amount of pure nitrogen. The adjusted mixture of pure synthesis gas flows to the synthesis gas compressors for compression to about 400-600 atmospheres. The gas to the N.S.U. is fairly pure hydrogen and is suitable for hydrogen treating of petroleum stocks. In this case the N.S.U. is omitted. If the sulfur content of the feed is very high, the processing scheme is slightly modified to remove sulfur compounds from the gas prior to shift conversion. The solution stripping operation can also be arranged to produce pure carbon dioxide if this is desired for other uses.

Operating Conditions: The partial oxidation unit is non-catalytic and operates at about 2600° F and 25-30 atmospheres.

Yield: 91 to 92 percent hydrogen on the basis of oil feed.

Commercial Installations: There are several commercial installations of the partial oxidation gas generation process using fuel oil as raw material. Variations of this process are being used at Northern Chemical Industries Inc., Searsport, Maine; Gonzales Chemicals Industries Inc., Guanica, Puerto Rico; Canadian Industries Ltd., Millhaven, Ontario; Republic of Korea, Chung Ju, Korea; and Asahi Chemical Industries Co., Ltd., Nokeahu, Japan.

References: PETROLEUM REFINER, Dec.'54,p156,May'55,p145.



Synthol Process— THE M. W. KELLOGG COMPANY

Application: A process for the synthesis of hydrocarbons and oxygenated chemicals from hydrogen and carbon monoxide.

Charge: Purified synthesis gas having a hydrogen to carbon monoxide ratio of 2.0 to 2.8.

Product: High olefin content hydrocarbons within the boiling point range of gasoline through heavy fuel oil as well as a wide range of oxygenated chemicals. The following is typical of the products produced from one type of recovery: LPG (50-100 psia vapor pressure), motor gasoline (85-90 CFRR clear), diesel oil, fuel oil, methanol, ethanol, methyl ethyl ketone, and acetone. Both water soluble and oil soluble organic acids may also be recovered.

Description: The feed gas is a mixture of hydrogen, carbon monoxide and carbon dioxide plus light hydrocarbons. This gas should be treated for the removal of sulfur compounds and resins if present. The purified feed enters the gas reforming unit where it is mixed with recycle tail gas from the recovery units and preheated by suitable heat exchange with the reformer effluent. Steam is then added to this mixture and the total stream is fed to the reforming chamber where it is mixed with essentially pure oxygen. Partial oxidation and reforming of the gas takes place over the catalyst in the reformer chamber at temperatures in the range of 1,600°-2,200° F and pressures in the order of 350 psig. The gases are then heat exchanged to generate almost all of the steam required for the feed and further exchanged and cooled to remove the water vapor. The reformed gas consists primarily of hydrogen and carbon monoxide and is fed to the Synthol unit.

The synthesis is carried out over an iron catalyst in a single stage powdered catalyst reaction system. The basic synthesis reaction is the hydrogenation of CO to yield hydrocarbons and water. Side reactions produce oxygenated compound also.

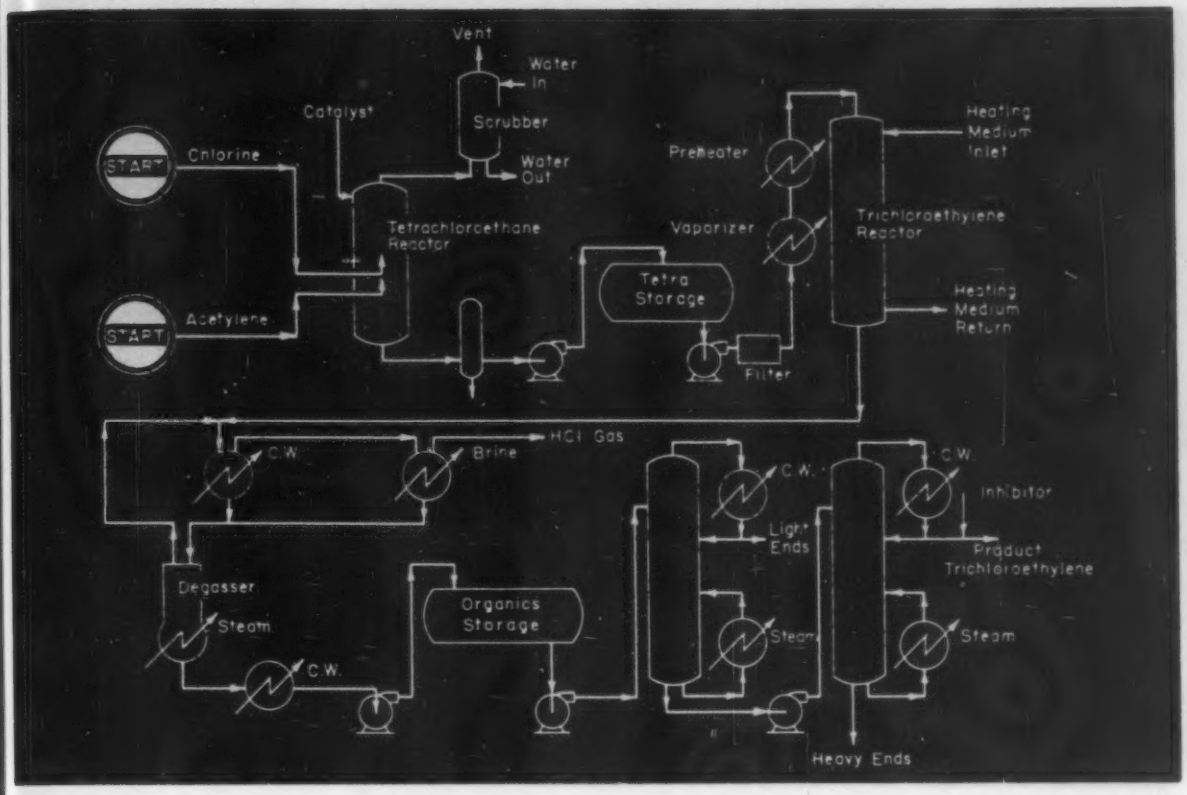
The synthesis gas coming from the reforming section is preheated and mixed with recycle gas before entering the reactor. Catalyst and gas mix in the transfer line and flow to the reaction zone. This transfer line velocity is 25-35 fps. The reactor operates with a gas velocity of 4-7 fps, temperature range of 590°-650° F, and pressure range of 250-350 psig. The catalyst-gas mixture moves through the reactor-cooler sections and into the settling zone. Here most of the catalyst disengages and recirculates down through the standpipe and slide valves. Cyclones installed in the settling zone remove most of the entrained fines.

Reactor effluent gas is quenched in a scrubbing tower where the remaining catalyst dust is removed. This fine catalyst is returned to the reaction zone in the form of a heavy oil slurry. A heavy oil product is removed from the bottom of the tower, and the other oil and chemical products pass overhead. The heat removal is by intermediate and top tower reflux. The overhead is cooled and condensed to yield the light oil and aqueous product liquids and the gas product, which is divided into recycle and net gas product.

The gas product passes on to recovery where the hydrocarbons are removed for conversion to polymer gasoline. The light and heavy oil products are processed to produce gasoline and the other products mentioned above. The aqueous product is processed for recovery of the pure chemicals noted above.

Yields: Conversions of carbon monoxide in the synthesis reactor are 95 percent-98 percent. Over-all carbon utilization from purified feed gas to useful products can be maintained at about 88 percent through recycle of unconverted gases regardless of conversion level. If the carbon dioxide, which must be scrubbed from the gas returning to the reforming unit can be utilized, this over-all figure is several percent higher.

Commercial Installations: This process is being employed in the South African Coal, Oil and Gas Corp. plant in the Union of South Africa.



Trichloroethylene— DETREX CHEMICAL INDUSTRIES, INC.

Application. A process for the manufacture of trichloroethylene.

Charge: Acetylene, 99 percent purity; chlorine, 99 percent purity.

Product: Trichloroethylene, 99+ percent purity.

Description: The process using the above raw materials consists of two main steps (1) the formation of tetrachloroethane (2) the conversion of tetrachloroethane to trichloroethylene by dehydrochlorination.

The tetrachloroethane is produced by feeding controlled amounts of chlorine and acetylene gas into a reactor charged with tetrachloroethane. The desired reaction is:

$$C_2H_2 + 2\,Cl_2 \rightarrow C_2H_2Cl_4$$

Suitable agitation is provided in the reactor to maintain homogeneous conditions and obtain good temperature control. A catalyst such as ferric chloride is usually employed at low concentration. Temperature is held in the range of 70°-85° C for atmospheric pressure operation. Since the reaction is exothermic cooling means must be used to maintain the desired reaction temperature. The process operates continuously with product being withdrawn as formed. Reactor off gases are sent to a scrubber before venting.

Dry tetrachloroethane is pumped from intermediate storage through a filter, vaporizer, preheater, and a catalytic reactor where it is dehydrochlorinated to produce trichloroethylene and HCl as shown by the following equation:

$$C_2H_2Cl_4 \rightarrow C_2HCl_3 + HCl$$

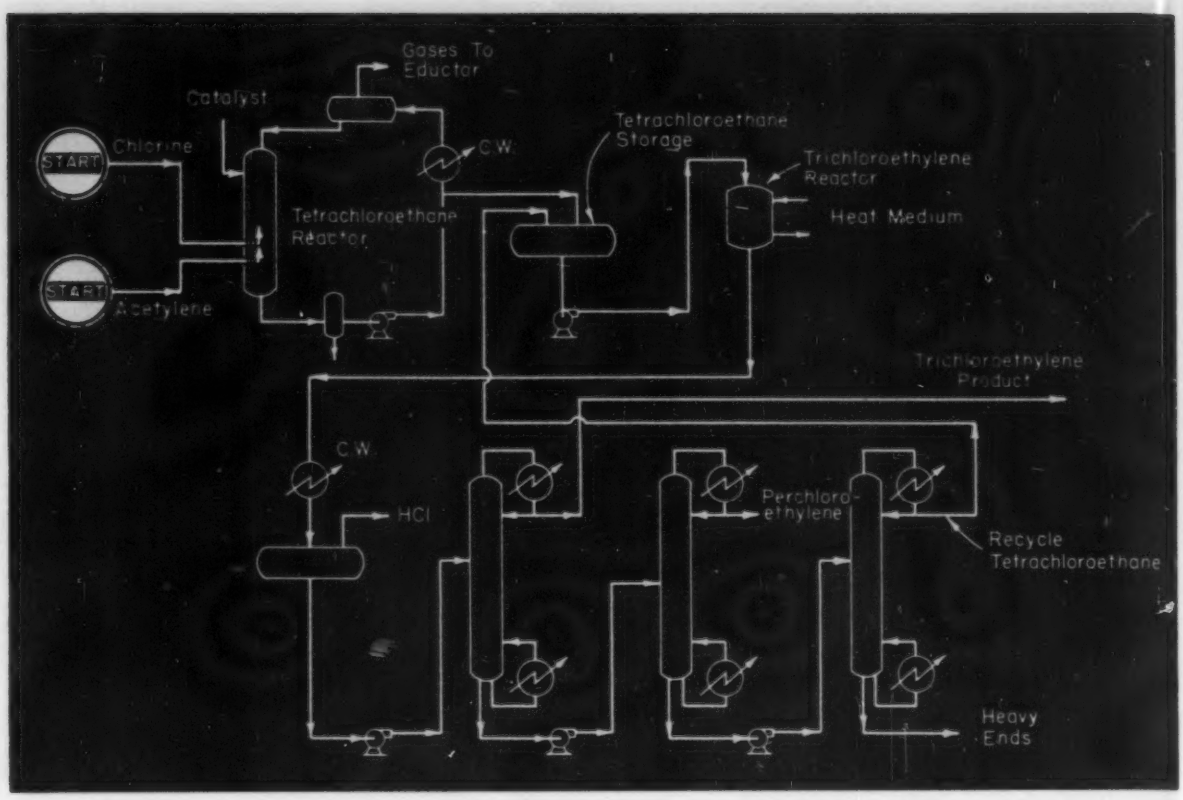
The standard catalyst is barium chloride (30 percent) deposited on carbon. Operating temperature range is 250°-300° C which must be maintaineed by heat input. Conversion is about 90 percent resulting in a product which is then 10 percent tetrachloroethane and 90 percent trichloroethylene. The chlorohydrocarbons are condensed, degassed to remove HCl, and sent to storage. The HCl is scrubbed and cooled to remove organics and is then available for other chemical processes.

The crude trichloroethylene is fractionated to obtain the final pure product which may then be stabilized for specific end uses.

Operating Conditions: Details are given in above text. Additional information can be found in Fiat Final Report No. 843.

Yields: Over-all process yields, acetylene or chlorine to trichloroethylene, are on the order of 90 percent.

Commercial Installations: Trichloroethylene by this or related processes is produced at the following locations: Columbia-Southern Chemical Corp., Barberton, Ohio; Detrex Chemical Industries, Inc., Ashtabula, Ohio; Dow Chemical Company, Freeport, Texas; E. I. DuPont de Nemours and Company, Niagara Falls, N. Y., and Wyandotte, Mich.; Hooker Chemical Corp., Niagara Falls, N. Y. and Tacoma, Wash.



Trichloroethylene

Application: A process for the manufacture of trichloroethylene.

Charge: Acetylene, 99 percent purity; chlorine, 99+ percent purity.

Product: Stabilized trichloroethylene, 99+ percent purity.

Description: The commercial manufacture of trichloroethylene from acetylene and chlorine consists of two main process steps: production of the intermediate tetrachloroethane, and production-purification of the final product trichloroethylene.

Acetylene and chlorine are combined in a liquid-phase, catalytic reaction to produce tetrachloroethane. The reactor is a steel tower through which a large recycle stream of tetrachloroethane reaction product is circulated. The exothermic heat of reaction is removed in an exchanger located in the circulating system. The conversion of acetylene and chlorine is essentially complete, and the tetrachloroethane yield is better than 95 percent.

Typical operating conditions for the reactor are: top temperature, 160° F; bottom temperature, 195° F; pressure, 0-5 psig; chlorine: acetylene molar feed ratio, 2.00-2.05. A catalyst such as antimony trichloride or ferric chloride is used in about 0.1 wt-percent concentration. Small amounts of hydrogen chloride and other noncondensibles are removed from the circulating system by an educator. Other by-products include dichloroethylene and hexachloroethane, the amounts depending on the ratio of primary reactants.

Tetrachloroethane is dehydrochlorinated thermally, catalytically, or by reaction with lime. The catalytic method predominates commercially, and will be described here. Previous issues of the handbook (e.g., PETROLEUM REFINER, November, 1957) include a description of the lime process.

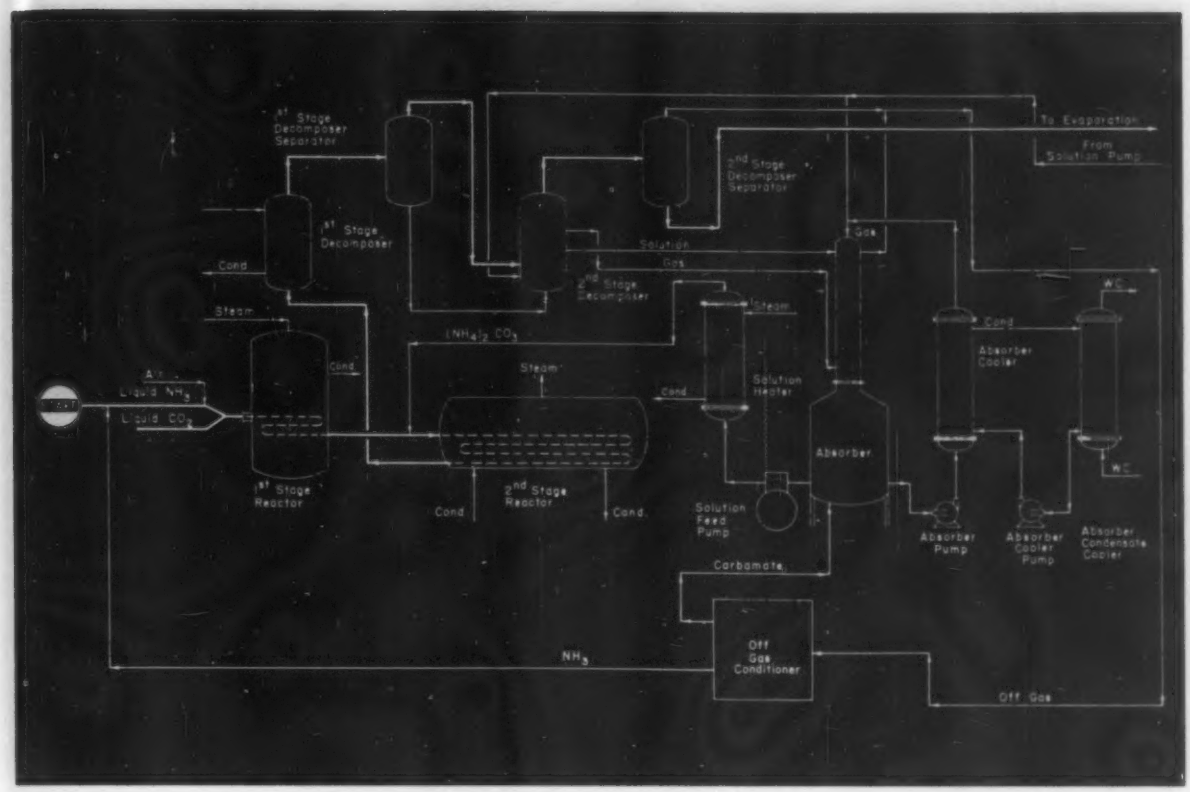
Tetrachloroethane is vaporized and passed through a packed-tube catalytic reactor, the heat of reaction being supplied by condensing heat medium. The catalyst is supported barium chloride. Typical reaction conditions are: 350°-700° F (temperature increasing with catalyst life); 10-20 psig; 200-300-hr^{-1} vapor space velocity; 80 percent conversion. Yield of trichloroethylene is 95 percent of theory or greater. Perchloroethylene is the principal by-product.

Organics are condensed from hydrogen chloride, the latter being available for direct use or for absorption in water. Purification of trichloroethylene is effected by conventional distillation, the tetrachloroethane being recycled to the reactor charge.

Operating Conditions: Details are given in above text.

Yields: Over-all process yields, acetylene or chlorine to trichloroethylene, are about 90 percent.

Commercial Installations: This process or a variation is used at the following plants: Columbia-Southern Chemical Corp., Barberton, Ohio; Detrex Chemical Industries, Ashtabula, Ohio; Dow Chemical Company, Midland, Michigan; E. I. du Pont de Nemours and Co., Niagara Falls, N. Y., and Wyandotte, Mich., Hooker Electrochemical Co., Niagara Falls, N. Y. and Tacoma, Wash.



Urea— CHEMICAL CONSTRUCTION CORPORATION

Application: A process for the manufacture of urea.

Charge: Liquid carbon dioxide and ammonia are the charge.

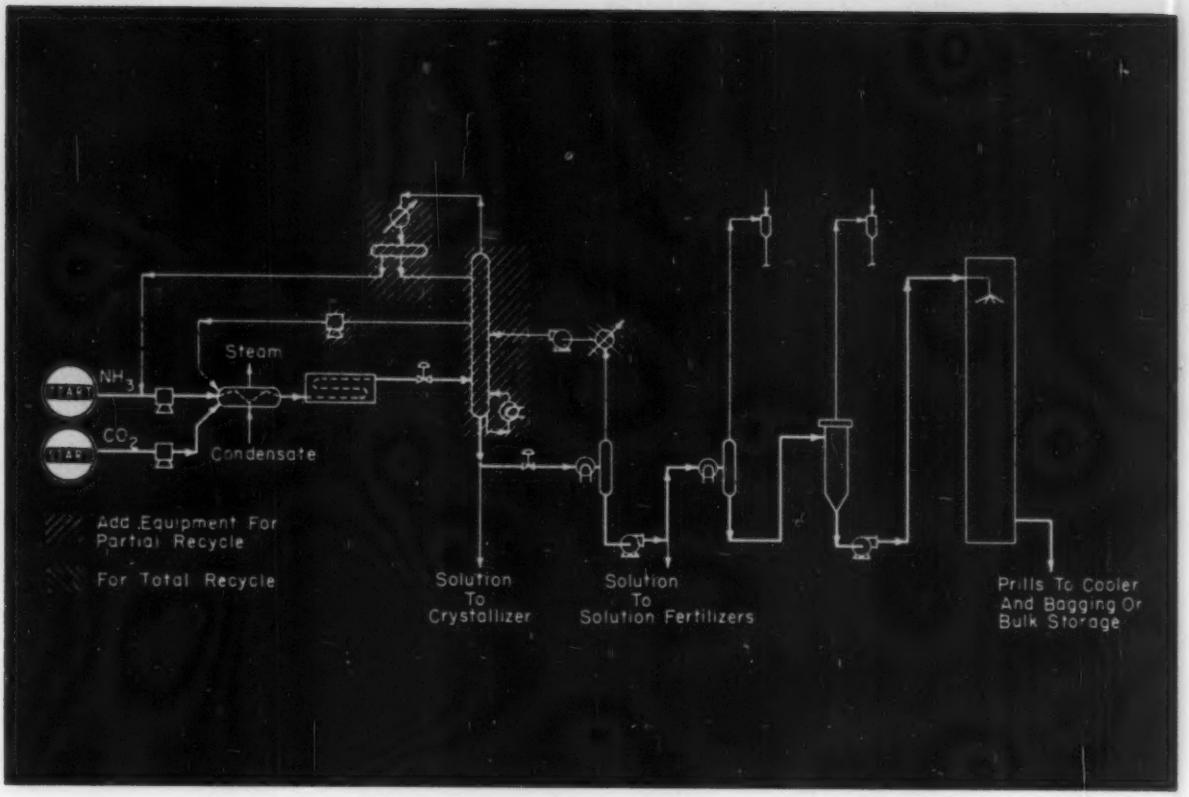
Product: Urea in the following forms: Urea solutions, spherical granules (prills) for fertilizer and cattle feed supplement, and crystals of high purity for plastics.

Description: In the Chemico process, using a ratio of ammonia to CO_2 of 2.5 : 1, a 50 percent conversion of ammonium carbamate to urea is achieved.

Carbon dioxide gas is compressed, condensed, and pumped to a pressure of approximately 3500 psia. Liquid ammonia is also pumped to the same pressure. The liquid CO_2 and NH_3 are fed to the first stage reactor. The mixture leaving the first reactor contains ammonium carbamate, urea, water and excess ammonia. This mixture flows directly to the internal coils of the second stage reactor, where 50 percent of the ammonium carbamate is converted to urea.

The reactor effluent is reduced to an intermediate pressure, and the unconverted carbamate is decomposed. The off gases are separated from the urea solution and can be recycled or sent to the client's ammonium nitrate or sulfate plant. The urea solution is reduced to atmospheric pressure in an evaporator feed tank and passed to an evaporator. The resulting 99.5 percent solution is pumped to a prilling tower, where urea prills, containing less than 1.0 percent biuret are formed.

Commercial Installations: Sumitomo Chemical Co., Ltd., Niihama, Japan, Nippon Gas Chemical Industries, Ltd., Niigata, Japan, Cyanamid of Canada, Ltd., Hamilton, Ontario, Monsanto Chemical Company, Eldorado, Arkansas, and Cooperative Farm Chemicals Association, Lawrence, Kansas.



Urea (DSM)—DUTCH STATE MINES

Application: A process for the manufacture of urea.

Charge: Liquid ammonia and gaseous carbon dioxide.

Products: Urea is produced as aqueous solutions, as prills for fertilizer or cattlefeed-supplement, or as crystals with exceptionally low biuret content for plastics or foliar application.

Description: Three process schemes are available to convert raw materials to products with conversion efficiencies of 45 percent to about 100 percent. Once-through design gives the lower conversions, partial recycle gives intermediate conversions, and total recycle gives the higher conversions. Choice from among these three schemes enables the most economic utilization of ammonia for production of urea or coproduction of urea and ammonium salts such as nitrate or sulfate.

The main difference in three schemes is in the recovery section of the plant. The designs of the reaction section and the finishing section are the same for all schemes. Specifications for raw materials and products are the same for all schemes.

Reactions: Carbon dioxide reacts rapidly and completely with ammonia in the liquid phase to form ammonium carbamate. At reactor operating conditions of about 2,800 psig and 350° F, part of the ammonium carbamate decomposes into urea and water. The extent of decomposition depends mainly upon the amount of ammonia that is present in the mixture. High ammonia concentrations favor decomposition up to about 70 percent. At the stoichiometric ratio of ammonia to carbon dioxide in the reactor mixture, about 45 percent of the carbamate decomposes to urea and water.

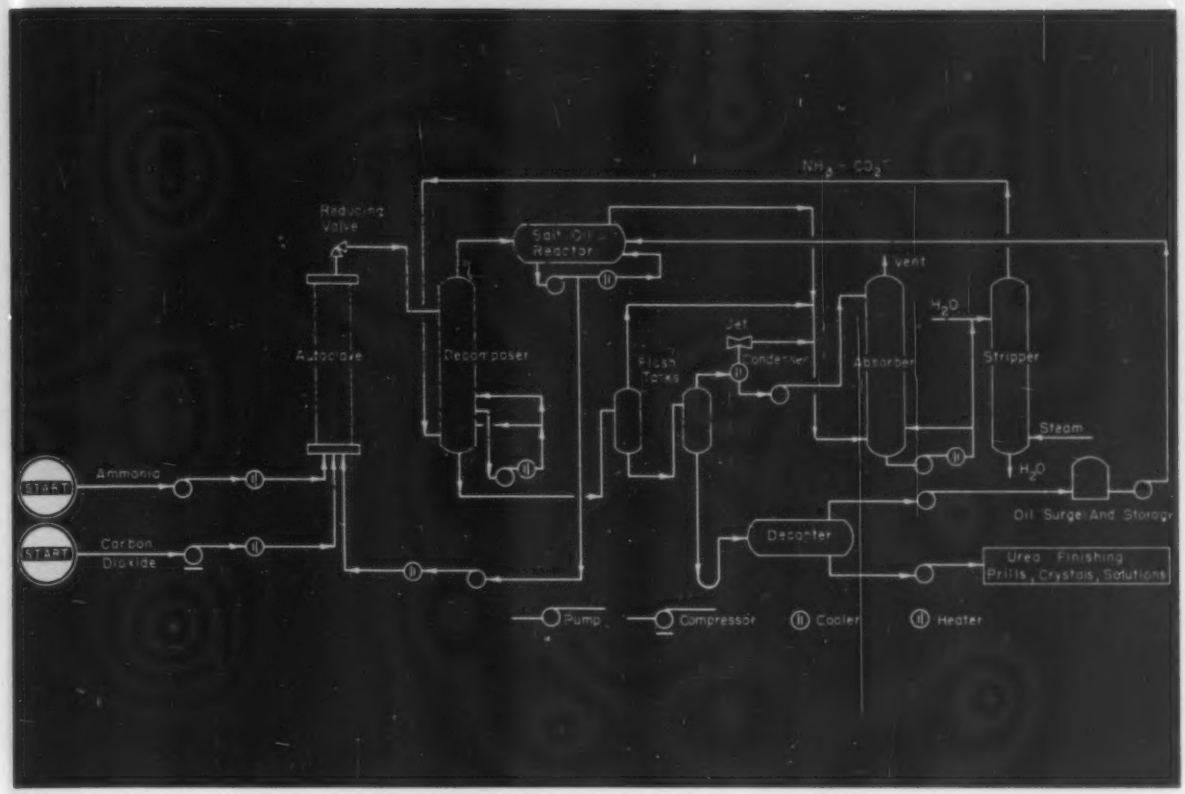
Recovery: When excess ammonia is present in the reactor mixture, the product is flashed at about 300 psig. Flashed ammonia is purified by fractionation, condensed and recycled to the reactor. A side draw of aqueous ammonium carbamate is taken from the ammonia stripper and pumped back to the reactor. The bottoms product from the ammonia stripper consisting of residual ammonium carbamate, urea, and water, is flashed to near atmospheric pressure in the decomposer to allow further stripping of ammonia and carbon dioxide. The remaining liquid consists of approximately 80 percent urea and 20 percent water.

Finishing: The main separation in the finishing section is between water and urea. Water is evaporated in two stages—each stage under progressively higher vacuum. The molten urea product from the second evaporator contains less than 0.3 percent moisture. No further drying of the product is necessary. Molten urea is prilled, cooled, and bagged or conveyed to bulk storage. In bulk storage, in a closed shed without air conditioning, the uncoated prilled product does not cake.

Yields: For a total recycle process, 100 tons a day of urea computed on 46 percent nitrogen requires about 58 tons of ammonia and 76 tons of carbon dioxide. These quantities allow for nominal losses. For a partial recycle or a once-through plant, the required raw materials are proportional to the conversion efficiency. At 70 percent conversion of ammonia, 100 tons of urea require about 83 tons of makeup ammonia. At 45 percent conversion, makeup ammonia is about 129 tons. For a 100-ton urea plant, offgas ammonia to ammonium salt production is 0 for total recycle, 25 tons for 70 percent conversion, and 71 tons for 45-percent conversion.

Materials: Materials for the reactors, decomposer, evaporators, and other equipment in high temperature service are stainless steels of the 300 Series. Linings of lead, silver, or other precious metals are not used. The use of oxygen under U.S. Patent 2,727,069 controls corrosion at a negligible rate.

Commercial Installations: Six commercial plants are presently in operation or under construction. Societe Carbochimique, Belgium. African Explosives and Chemical Industries, South Africa. Federation Chemicals, British West Indies. Union Rheinische Braunkohlen Kraftstaffe. A.G., Germany. Associaxione Nazionale De L'Industria Chimica, Italy. Dutch State Mines, Holland. The total capacity of these plants is about 1,250 tons a day—about a half million tons of urea per year. Of this total, over 300 tons are in operation. The Federation Chemicals' 70-ton-per-day plant, designed and built by C F Braun and Co., will start production in the fall of 1959.



Urea— FOSTER WHEELER CORPORATION

Application: A process for the manufacture of urea.

Charge: Ammonia and carbon dioxide.

Products: Prilled solid urea, technical grade crystals, solutions.

Description: Urea synthesis, in the Pechiney-Grace process, essentially is achieved by the non-catalytic reaction of ammonia and carbon dioxide at a pressure of 3000 psig. The outstanding feature of the process is the use of a neutral oil in which unconverted feed gases in the form of an ammonium carbamate slurry is recycled to the reactor. The products of the reaction are highly corrosive and the neutral oil circulating medium minimizes attack of metal parts and also moderates temperature variations in the reactor.

Carbon dioxide compressed to reaction pressure, treated to remove any residual sulfur and oxygen, is preheated and charged to the reactor. Liquid anhydrous ammonia is preheated and also enters the reactor. The recycle stream containing 35-40 percent ammonium carbamate solid in a highly dispersed slurry-in-oil also enters the reactor. The primary reaction is to form ammonium carbamate from ammonia and carbon dioxide.

This is a highly exothermic reaction and supplies the heat for the secondary reaction, the dehydration of carbamate to urea and water, which is endothermic. The oil carrier thus serves as a thermal fly wheel storing the heat liberated by the first reaction and releasing it for the second reaction.

The effluent from the reactor, viz., urea, unreacted carbamate, water and carrier oil flows through a pressure reducing valve from the 3000 psig reactor pressure to approximately 60 psig and into the decomposer where heat is applied to decompose carbamate into ammonia and carbon dioxide.

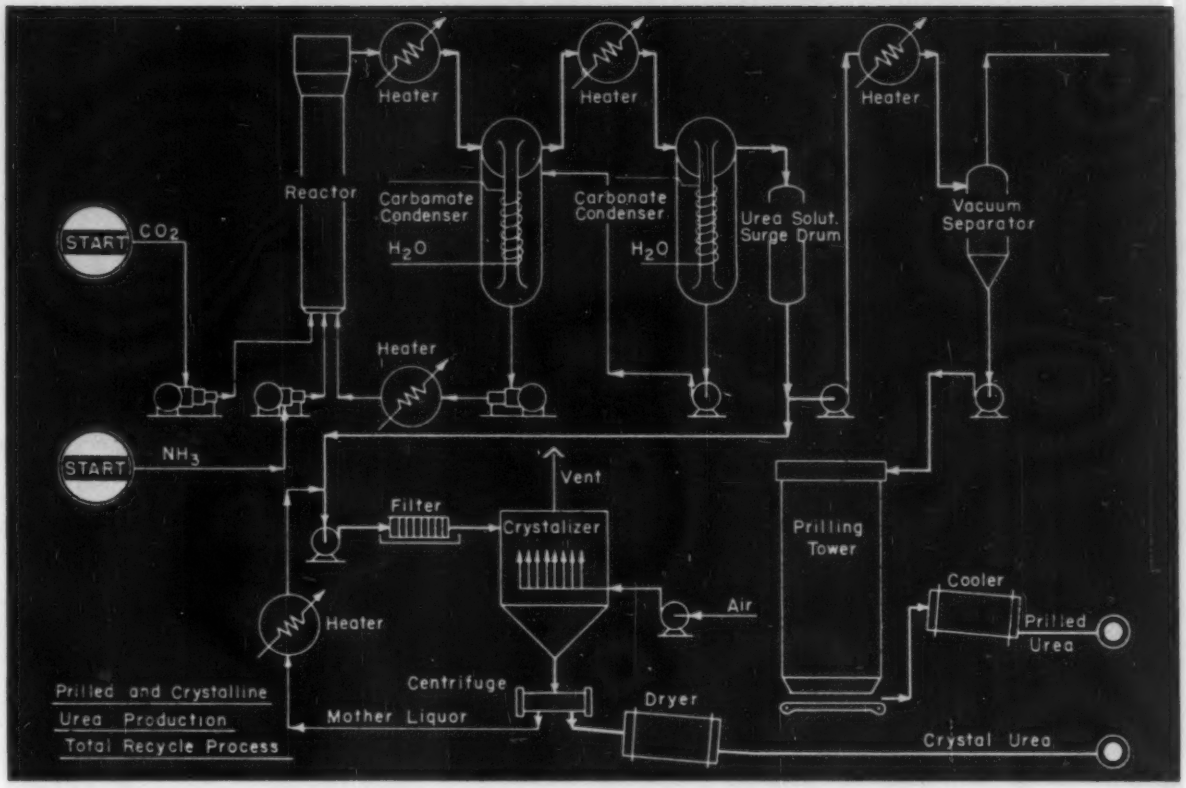
The aqueous urea solution and oil flows through atmospheric and sub-atmospheric flash systems to the decanter where the carrier oil settles as a top layer and is pumped to the oil surge and storage tank. The aqueous urea solution withdrawn from the bottom of the decanter is pumped to the urea finishing sections.

Uncoverted ammonia and carbon dioxide gases, from the decomposer, flow to the salt oil reactor where they combine to form solid ammonium carbamate finely dispersed in the circulating oil. This recycle stream of ammonium carbamate and oil is pumped back to the synthesis autoclave.

Ammonia and carbon dioxide gases released in various parts of the unit flow to an absorption-recovery section and are recycled to the decomposer.

Operating Conditions: Essential operating conditions are given in the above description.

Commercial Installations: Grand River Chemical Division of Deere and Company, Pyor, Okla., Grace Chemical Co., Division of W. R. Grace & Co., Memphis, Tenn. and 330 Ton/day installation by Government of Indonesia.



Urea— MONTECATINI

Application: A process for the manufacture of synthetic urea.

Charge: Liquid ammonia and gaseous carbon dioxide free from sulfur compounds and having, at least, a 97 percent purity.

Product: Fertilizer grade urea in spherical granules or technical grade urea in crystals.

Description: Ammonia and carbon dioxide are pressurized into the reactor where, at a pressure of 2700 psig and at a temperature of 360° F. they react forming ammonium carbamate, which in turn is converted into urea plus water.

It is necessary to maintain in the reactor, because of its favorable influence upon the conversion of carbamate into urea, an excess of ammonia in respect of the stoichiometric value. In fact, the extent of urea formation is limited by equilibrium considerations so that in the reactor effluent there are, in addition to urea and water, some carbamate and free ammonia. The last two components must be separated from the urea solution.

The reactor effluent is first expanded to 300 psig. During this operation a gaseous mixture of NH_3 and CO_2 is freed and after condensation is recycled to the reactor. By means of this liquid recycle it is possible to return to the reactor a large portion of unreacted ammonia and carbon dioxide as an aqueous solution. The remaining NH_3 and CO_2 are vaporized from the urea solution by means of a second expansion step to about atmospheric pressure.

The gaseous mixture which is thus made available is condensed and sent back to the cycle by introducing it into the carbamate condenser.

This method of recycling NH_3 and CO_2 as an aqueous solution represents a substantial improvement over other methods which recover the same components in the gaseous state and recycle them to the reactor after compression. In this way, remarkable savings can be achieved in electric power consumption and greater simplicity in the construction design of the plant.

The urea solution, free from NH_3 and CO_2 is further concentrated in a vacuum concentrator and is then pumped to sprayers in a prilling tower. Here the solution is subdivided in the form of small droplets which, falling vertically in an air stream flowing upwards, are solidified, forming prills.

Prilled urea is particularly suitable for agricultural uses. The crystalline product having a higher purity is preferred for technical uses and is obtained from the concentrated urea solution by means of crystallization and centrifugation.

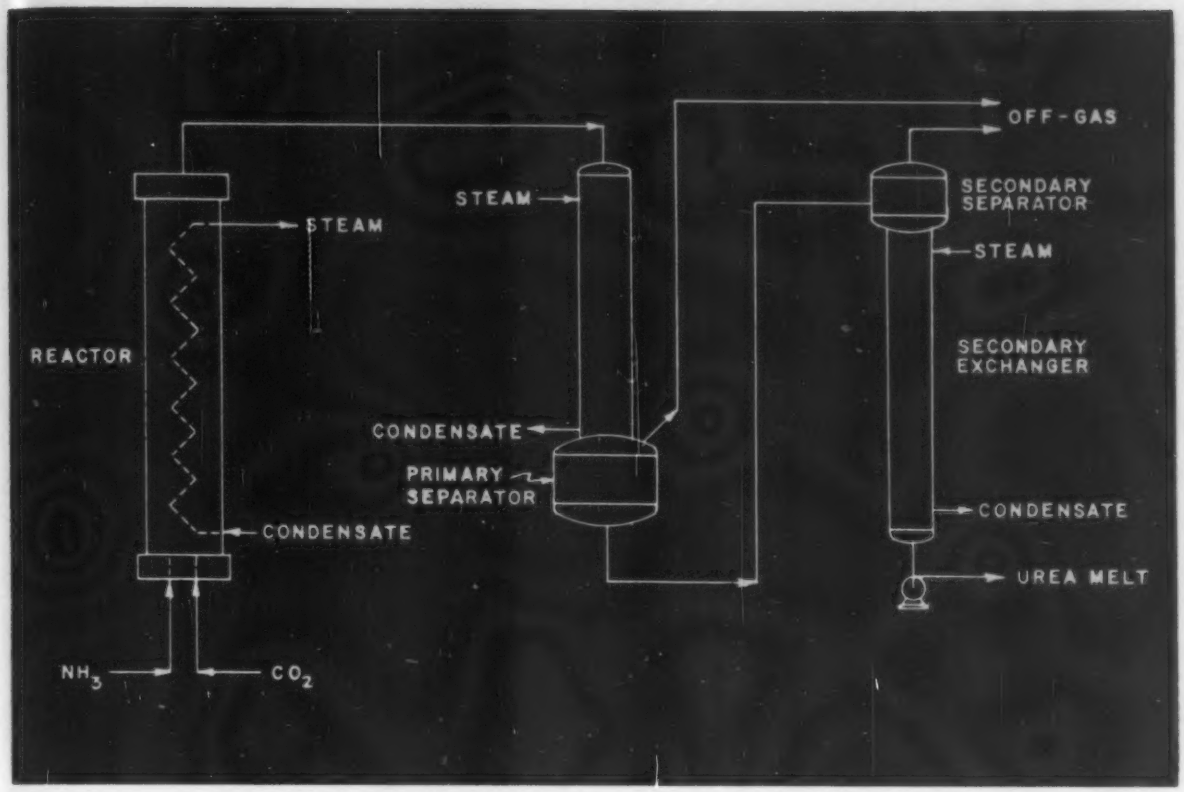
Operating Conditions: As already mentioned, the reactor pressure is from 2500 to 2800 psig and a temperature of 350° to 360° F. is maintained.

Yields: Conversion of ammonia and carbon dioxide into urea is total. Raw material requirements per ton of urea (46 percent N_2) are 0.600 ton of NH_3 and 0.770 ton of CO_2.

Corrosion Problems: Mild and carefully controlled reaction conditions are used in this new process to eliminate corrosion, a major problem in urea plants. By careful selection of composition and temperature in the reactor, it is possible to use with excellent results, commercially available stainless steel for reactor lining and for other surfaces exposed to corrosion.

Commercial Installations: 32 commercial plants are presently in operation or under construction all over the world, with a total annual capacity of 700,000 metric tons of urea.

U.S. Plants in Operation: Shell Chemical Corp., Ventura, Calif.; Spencer Chemical Co., Vicksburg, Miss.; Spencer Chem. Co., Henderson, Ky. Under construction: SunOlin Chem. Corp., North Claymont, Del.



Urea (Inventa-Vulcan)— VULCAN-CINCINNATI, INCORPORATED

Application: A process for the manufacture of urea.

Charge: Anhydrous ammonia and carbon dioxide.

Description: In this process urea is synthesized by the following reactions:

$$CO_2 + 2NH_3 \rightleftarrows \underset{\text{(Carbamate)}}{NH_2COONH_4} \rightleftarrows \underset{\text{(Urea)}}{NH_2CONH_2} + H_2O$$

Liquid ammonia and liquid or gaseous carbon dioxide are reacted to form ammonium carbamate, urea and water with the evolution of a large amount of heat. The temperature of the process is controlled by removing this heat with water circulated through an exchanger in the reactor. The heat picked up in the circulated water is recovered as steam for use elsewhere in the process.

Urea, carbamate and water flow from the reactor to equipment where the carbamate is decomposed into ammonia and carbon dioxide. The off-gas is separated from the liquid urea solution and flows to the recycle section for recovery or to uses as described below. Liquid urea from this point can be used to make solution products or can be further processed by prilling to yield feed, fertilizer and industrial grade solids, by crystalization to produce industrial and pharmaceutical grade solids, or by pelletizing, granulation, etc.

This process features simplicity and low costs. The process is non-catalytic and requires no internal recirculation of any reactant or carrier. Even though the process fluid is extremely corrosive under the operating conditions, the use of a special alloy and close control of operating conditions has essentially eliminated corrosion. Reactor life in excess of ten years has been proven.

The process is versatile and can be operated on a once-through basis with the off-gas at sufficient pressure for use in production of ammonia solutions or nitric acid for neutralization of nitric or sulfuric acids. However, if none of these uses can be made of the off-gas, a recycle unit can be added. If necessary, the recycle unit can recover all of the off-gas and return it to the synthesis operation. Alternatively, the recycle unit can provide for part of the ammonia to be recovered and returned to synthesis, with the balance of the ammonia being utilized for solutions or neutralization of acids.

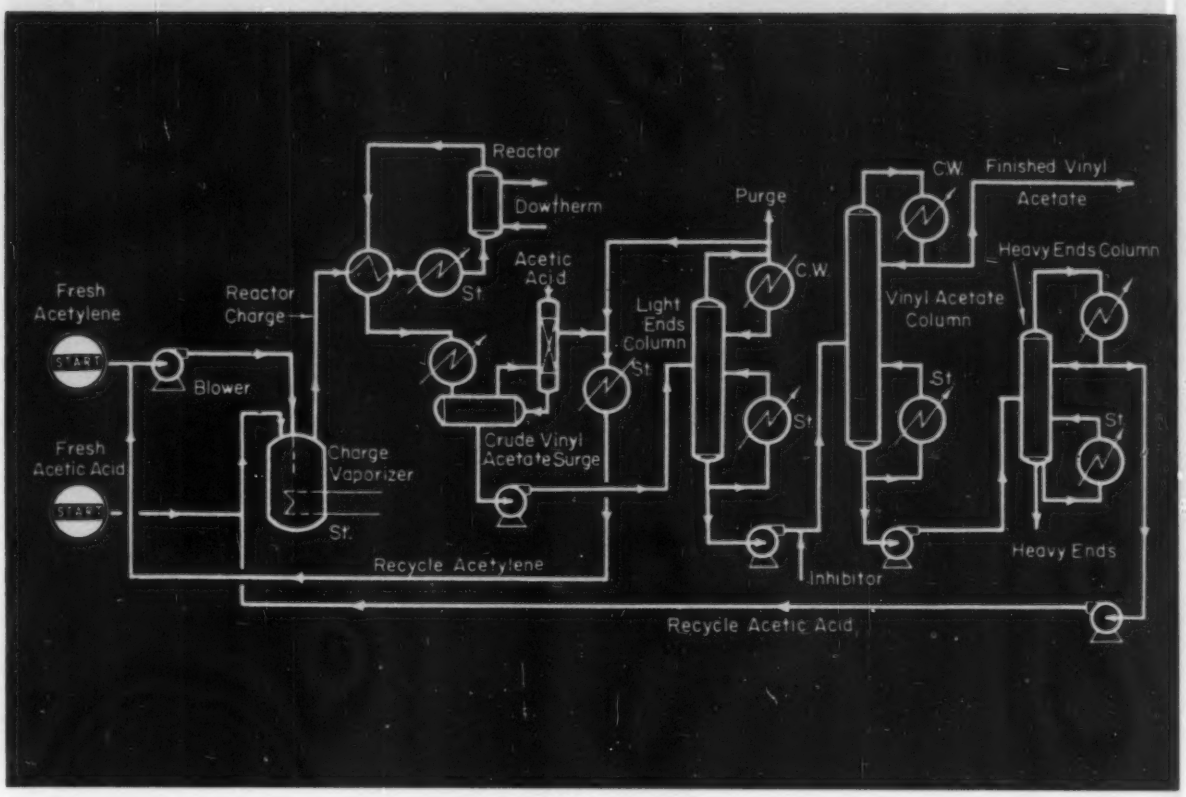
The process is extremely easy to start up and operate. Four United States plants were on stream and operating at design capacity in a matter of hours.

Operating Conditions: The reactor pressure is 170-200 atmospheres and 160°-190° C.

Yields: A 100 ton per day plant requires 56.7 tons of ammonia and 73.4 tons of carbon dioxide.

Commercial Installations: Holzverzuckerungs, A. G., Ems, Switzerland; Sohio Petroleum Company; Southern Nitrogen Company; Taiwan Fertilizer Co., Ltd., Republic of Korea (2 plants); Hercules Powder Co.; Pakistan Development Corp., Mississippi Chemical Corp.; Consolidated Mining & Smelting Co. of Canada, Ltd. Three U.S. plants have once-through operations and one employs a partial recycle system. The five overseas plants and the Canadian plant are equipped with total recycle units.

Reference: *Chemical Engineering,* Jan. 26, 1959.



Vinyl Acetate

Application: A process for manufacture of monomeric vinyl acetate.

Charge: Glacial acetic acid (99.5 percent purity); acetylene, 99.5 percent purity.

Product: Vinyl acetate monomer, 99.5+ percent purity.

Description: Vinyl acetate is produced commercially by the chemical combination of acetic acid and acetylene. The reaction is catalytic and may be carried out in either the liquid or the vapor phase. The vapor phase process will be discussed here, since it has in general replaced the older and less efficient liquid-phase operation.

Acetylene generated from calcium carbide is used in most commercial vinyl acetate plants in the United States and Canada. Certain materials present in acetylene from this source act as vinyl acetate catalyst poisons and must be removed. It will be assumed here that the acetylene has been washed (e.g., by chromic-sulfuric acids) and dried, and that it contains no phosphine or sulfur compounds.

Glacial acetic acid from outside the battery limits is blended with recycle acid in the charge vaporizer, which is a stainless steel tank equipped with acetylene sparger, steam coils, and entrainment separator. Recycle plus fresh make-up acetylene enters the tank through the sparger and passes up through the acid. The temperature of the mixture is controlled on the basis of the desired ratio of acetylene to acetic acid in the vapor passing overhead. Typical operating conditions for the charge vaporizer are 4-5 psig and 160°-180° F.

The vaporized charge is preheated first by exchange with the reactor effluent and finally with steam (or heat transfer medium) before it passes to the base of the reactor. The conversion to vinyl acetate takes place in a vertical tubular unit of stainless steel construction. Typically, the tubes are 2-inch diameter by about 12 feet long, and are packed with a granular activated carbon impregnated with 20-30 wt-percent zinc acetate catalyst. The reaction is of the "hot spot" type, with the catalyst gradually deteriorating and requiring replacement very few months. For a fresh catalyst charge, the reactants are preheated to about 350° F, but as the catalyst ages this temperature is gradually increased until at the end of a cycle the reactants are preheated to about 400° F. The reaction is relatively clean at all times, with yields on the order of 95 percent of theory or better. By-products are principally acetaldehyde and ethylidene diacetate.

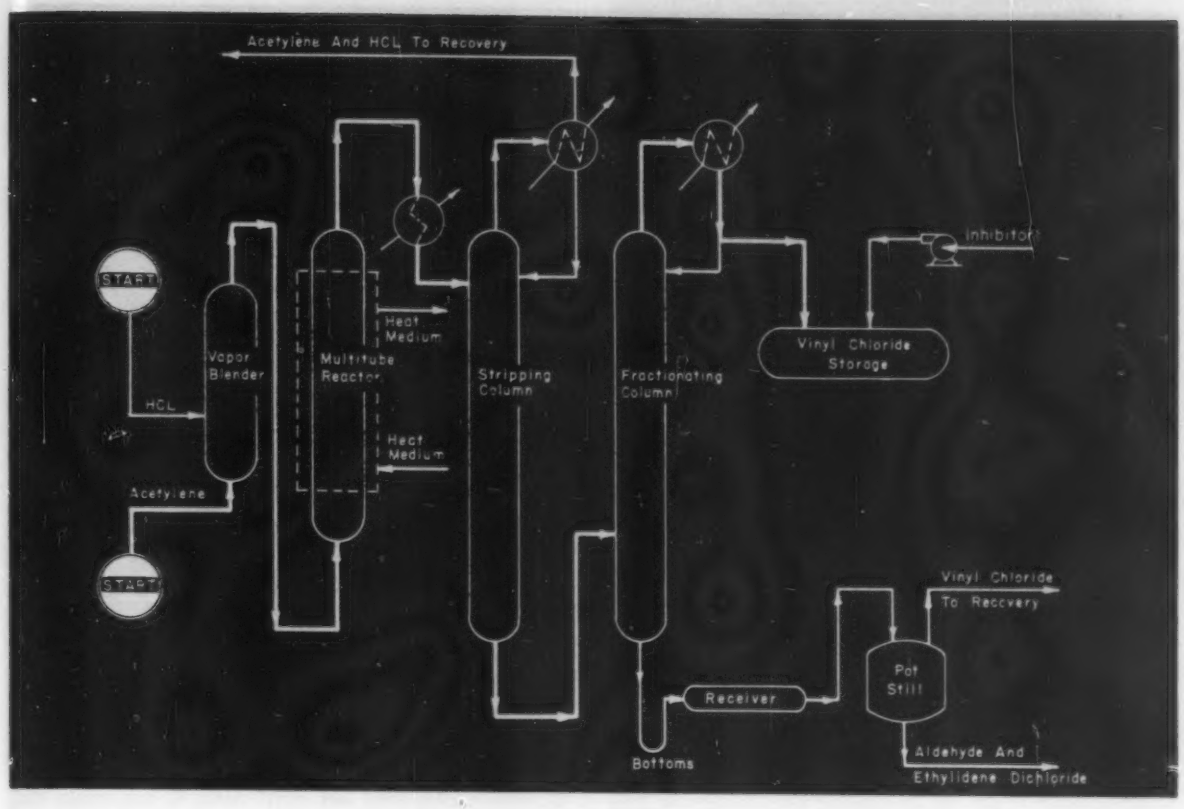
In addition to the temperature conditions noted, typical reaction conditions include: acetylene to acetic acid molar ratio in charge, 4-5 to 1; temperature rise of gases passing through the bed, 10°-20° F; operating pressure, 2-3 psig; vapor space velocity, 300-400 $hr.^{-1}$. Acetic acid conversion is controlled to provide an optimum recycle from the distillation section, but in general is high—80 percent or more. The exothermic heat of reaction is removed by heat transfer medium in the shell side of the reactor.

The effluent gases from the reactor are cooled in two stages, first by exchange with feed vapors and finally by exchange with water or other coolant. A mixture of crude vinyl acetate and unreacted acetic acid is condensed in this step. Non-condensibles, primarily acetylene, pass overhead and recycle to the reactor.

Pure vinyl acetate monomer is obtained from the crude in a series of atmospheric distillation steps. In the first column light ends such as residual acetylene, acetaldehyde, and acetone are removed; the acetylene may be separated and recycled to the reactor. The bottoms from this column pass to the vinyl acetate finishing column, wherein a sharp separation is made between vinyl acetate and acetic acid. A polymerization inhibitor may be used in this step to prevent column fouling. The acetic acid from the vinyl acetate column passes to a cleanup still for removal of heavy reaction products and inhibitor. Depending upon product distribution from the reactor, an additional column may be required to separate a fraction intermediate between vinyl acetate and acetic acid. The acid is recycled to the charge vaporizer. The finished vinyl acetate has a purity of 99.5 percent or higher. It is stabilized either with 0.03 percent diphenylamine (permanent stabilizer which must be removed before the monomer can be polymerized) or 20 ppm hydroquinone (temporary stabilizer). Storage and shipment are carred out in steel equipment.

Yields: Over-all process yields are 92-98 percent on acetylene 95-99 percent on acetic acid.

Commercial Installations: This process or a variation is used at the following plants: Air Reduction Co., Calvert City, Ky.; Union Carbide Chemicals Co., Niagara Falls, N. Y. and Texas City, Tex.; Shawinigan Chemicals, Ltd., Shawinigan Falls, Quebec; E. I. duPont de Nemours & Co., Niagara Falls, N. Y.



Vinyl Chloride From Acetylene— NAUGATUCK CHEMICAL

Application: The process for the manufacture of vinyl chloride.

Charge: Acetylene and hydrogen chloride are the charge.

Product: The product is vinyl chloride monomer.

Description: Hydrogen chloride gas with a water content of less than 0.2 weight percent is mixed with dry acetylene in a vapor blender to react in equal molar quantities. The hydrogen chloride and acetylene must be dried to avoid excessive corrosion and to hold down the quantity of acetaldehyde formed as a by-product. From the vapor blender the gas mixture is fed to multi-tube reactors. The reactors are connected in banks for parallel flow of gases. Each tube is packed with activated carbon pellets impregnated with a catalyst containing mercuric chloride.

The reaction must be initiated by heat supplied to the reaction mass, using a circulating heating medium in the shell side of the reactor. Once the reaction is started, it is highly exothermic and the circulating medium used to supply heat is now used as a coolant.

The main reaction proceeds as follows:

$$HC = CH + HCl \rightarrow CH_2 = CHCl \text{ (vinyl chloride)}$$

One of the side reactions for the formation of acetaldehyde by hydration of acetylene is as follows:

$$HC = CH + H_2O \rightarrow CH_3CHO \text{ (acetaldehyde)}$$

The other side reaction for the formation of ethylidene dichloride proceeds as follows:

$$CH_2 = CHCL + HCL \rightarrow CH_3 - CHCL_2 \text{ (ethylidene (dichloride)}$$

The temperature in the reactor is controlled to about 200° F. The exact temperature is dependent upon the catalyst age and physical condition.

Gases from the reactor contain the product vinyl chloride, as well as by-products such as ethylidene dichloride and aldehydes. Small amounts of unreacted hydrogen chloride and acetylene are also present. These gases are cooled before being fed to a combination stripping and fractionating operation. In this operation the unreacted acetylene and hydrogen chloride are removed from the crude vinyl chloride.

In a fractionating column the crude vinyl chloride is then purified and taken as overhead product. The ethylidene dichloride and the aldehydes are removed from the bottom of this tower. These by-products then go to a pot still, where the residual vinyl chloride is removed from the by-products.

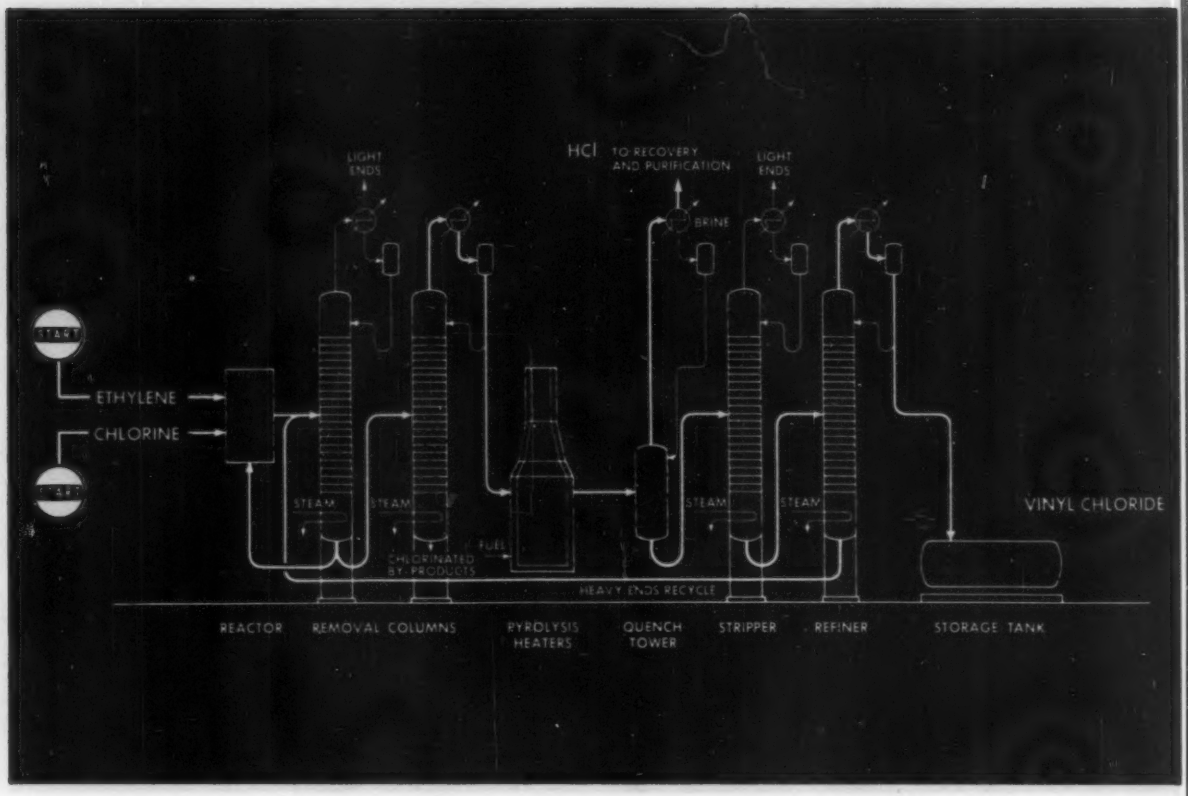
The pure vinyl chloride product goes overhead and flows to stainless steel storage tanks. A small amount of phenol or tertiary butyl catechol may be added as a polymerization inhibitor.

Operating Conditions: The major operating conditions are given in the text of the description.

Yields: Typical yield data are given below:

Yield of vinyl chloride based on acetylene —95 to 98 percent.

Acetylene Consumption: Forty-two to 45 pounds per 100 pounds of vinyl chloride.



Vinyl Chloride From Ethylene— SCIENTIFIC DESIGN COMPANY, INCORPORATED

Application: A process for the manufacture of vinyl chloride.

Charge: Ethylene and chlorine gases.

Product: High purity vinyl chloride.

Description: Ethylene and chlorine gases are charged to a reactor system containing catalyst and an excess of ethylene dichloride as a solvent for the feed gases. The addition reaction is extremely rapid and goes essentially to completion without any appreciable formation of higher chlorinated compounds.

The recovered crude ethylene dichloride is carefully purified in a distillation train of two columns. The first column removes traces of unreacted ethylene and any ethane or other low boiling inert materials present in the feed stocks. The second column removes traces of by-product higher-boiling chlorinated compounds which are only created to a small extent in the efficient reaction system, but are present in the recycled dichloroethane.

The purified ethylene dichloride is then cracked at high temperature in direct fired furnaces to yield a crude mixture containing principally hydrogen chloride, vinyl chloride and unreacted ethylene dichloride. The effluent gases are quenched rapidly for maximum recovery of the desired products. Crude hydrogen chloride gas is discharged to an aqueous scrubber-stripper system for purification. Liquid cracked products are refined in a distillation train which includes two columns—one to remove light ends and the other to remove unreacted ethylene dichloride and other heavy ends formed in the pyrolysis.

Economics: This process utilizes ethylene and chlorine, or ethylene dichloride as raw materials. By-product hydrogen chloride is produced and must be disposed of in some manner. Recent estimates of thermal cracking monomer-producing plants starting with ethylene and chlorine show an investment of less than six cents per pound of annual capacity for complete process plants within battery-limits.

Operator's Handbook for Gasoline Plants

Part 5—Reciprocating Pumps

One of a series that simplifies operations and equipment for the new and experienced operator in a natural gasoline plant

Manufacturing Department, Bay Petroleum Company, A Division of Tennessee Gas Transmission Co., Houston

A PUMP may be described as any device used for the transference of fluids. Pumps used in natural gasoline plants are of many types, but have been classed as reciprocating or rotary. Rotary pumps will be described in Part 6.

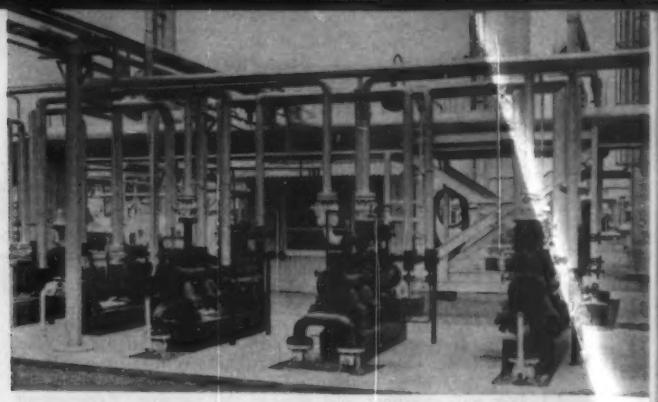
Reciprocating pumps are the oldest and best known form of pump. The delivery of a fluid is effected by the displacement of a piston or a plunger.

A steam driven piston pump consists of two cylinders, one for the power (steam) and one for the pumped fluid. Each cylinder is equipped with a piston connected to a common rod. The power piston is forced from one end of its cylinder to the other by steam pressure. This movement discharges the pumped fluid from its cylinder through a discharge valve. On the reverse stroke the suction valve opens and the fluid cylinder is again filled. This type pump is known as a single acting pump since it discharges only when stroking in one direction. The flow of the fluid is intermittent since the piston must reverse its direction at the end of each stroke.

The double acting pump has a set of suction and discharge valves in each end of the fluid cylinder. With this type pump, the flow of fluid is much smoother since there is movement of fluid when the pump is stroking in either direction.

Plunger pumps are used for higher delivery pressures than piston pumps of equal size. In the plunger pump, the single acting plungers work through packing in the heads of the cylinder. The cylinder diameter is approximately that of the plunger. With the outside packing, any leakage is visible to the operator. This fact, plus the greater ease of repacking, results in better maintenance.

Maintenance and repair of any pump should follow the manual supplied by the manufacturer. However, the following operating troubles and maintenance hints can be generalized.



Steam-driven reciprocating pumps (right) require little attention, but the operator should not be complacent.

OPERATING TROUBLES

The three most common troubles found with positive displacement pumps are excess stuffing box leakage, hammering and pounding noises, and overheating.

Stuffing box leakage that has started to trickle instead of drip is excessive. If the boxes are packed with V type rings and this much leakage occurs as soon as the machine is started, the packing is upside down. It is highly improbable that V packing will leak very much when new. If it does and has been installed right side up, the plunger is worn out or misaligned. Packing that is leaking excessively will sometimes cause permanent damage to the plungers, particularly if the packing is metal.

Hammering and pounding indicates that something is wrong with the suction system; the liquid end or the power end. The liquid end valves are most apt to cause noise characterized by a pronounced ringing as if the piping were being struck with a hammer. This is caused by shock waves being set up in the piping. Two possible reasons for this behavior are:

1. The pump is not getting enough liquid due to a clogged suction line or the supply pressure is low due to low level in the supply tank. When the supply is from a source such as a city water main, plant distribution system, or centrifugal booster pump, the operator should check for adequate supply pressure.

2. The valves are "hanging up." The valve disc may wear as it rubs against the guide surfaces in the spring retainer and then bind. Look for notches in the side of the valve disc. If present, replace the disc. One or more broken springs will also cause faulty valve closure. The power end will cause noise if the main bearings are loose or damaged. Excessive clearance in the crosshead guides will sometimes cause a dull thudding sound. A burned-out connecting rod bearing usually makes a sharp clattering sound.

Overheating of any part indicates excess friction. Oil sump temperatures in excess of 150° F when the pumping temperature is less than 120° F should be taken as a sign of trouble somewhere in the power end.

MAINTENANCE

These pumps require very little attention in general. This very fact will lead the operator into a state of com-

placency that is dangerous. For proper maintenance:

1. Drain the liquid end every time the pump is shut down for an extended period. Most commonly handled liquids will either corrode the metal parts or form a deposit of some sort on the exposed surfaces. If the pump is pumping water in an unheated installation where the temperature will fall below freezing, the valve service should be removed and the entire liquid end carefully drained. It is important to remove the water from the small pocket in between the valve cartridges. This pocket is the end of the plunger bore and if ice forms in it, severe damage can be done to the plunger and its associated parts.

2. Cover the liquid end parts with a heavy oil or grease to protect them from corrosion during storage or extended down time.

3. Change oil regularly as outlined by your lubrication schedule.

4. Check the relief valve setting regularly. Even if a completely noncorrosive liquid is being pumped, the valve can still be damaged by moisture and other airborne contaminants accumulating into it from the discharge side. If the liquid being pumped is corrosive, such as aerated water, the valve can be damaged from both sides and, as a result, the setting can get out of adjustment. Do not let the relief valve leak. Continuous leakage at high pressure will wire draw the seating surfaces. As soon as a leak is discovered, the valve should be dismantled and if necessary lapped in.

5. Inspect the liquid end valves at regular intervals as dictated by experience. Some liquids will cause rapid valve deterioration while others will not.

6. Plunger packings are the most controversial equipment in the hydraulic field. The plungers should run with a film of liquid on them for lubrication. If there is no evidence of any liquid leaking past the packing, wait and see if excess heat develops. If the gland and barrels do get hot, it may be necessary to remove one or more packing rings before the packing will leak enough to keep the plunger lubricated. Note that one or two drops a minute is near optimum leakage. Anything more than a trickle can be taken as evidence that the packing needs attention. The conditions influencing packing life are so varied that it is difficult to make specific packing recommendations. On the other hand, the pump must be packed and the packing cared for. To get maximum life from packing, one pump manufacturer has made these recommendations:

- Keep the packing properly adjusted. Never permit the plunger to run dry. This will invariably result in scored plungers and packing failure.
- The plunger must be maintained in absolute alignment if prolonged packing life is to be realized. The plunger wears as it runs through the packing and when the wear becomes great enough (a few thousandths of an inch), the packing will no longer be able to seal against the plunger. Regular checks of the plunger condition should be made to see whether scoring has started. Experience will dictate the frequency of these inspections.
- Metal plungers over 1 inch in diameter may be turned down and polished to as much as ⅛ inch undersize in order to true them up and/or remove score marks. If this is done, a new throat liner and metal packing ring bored to the new plunger diameter must be used to prevent packing extrusion. Oversize packing will also be required. Note that a loss of capacity will result.

TO BE CONTINUED

TIPS ON PACKING

V-type packing is usually recommended for higher pressures. It is designed to be self-sealing and therefore nonadjustable. One of its big drawbacks is that new packing will very often seal so effectively that the plunger and box will overheat and destroy the packing. Experiments conducted by one manufacturer showed that only ½ to ⅔ of the required number of rings should be installed when using a new set of packing. After the pump has run for an hour or two, the balance of the stack can usually be installed without overheating. This style of packing must be oiled during installation and break-in for optimum performance. If oil will contaminate the liquid handled, or damage the packing, some other lubricant such as wax, graphite or molybdenum disulfide should be used.

V-packing comes in various forms and combinations. Generally, the rings will all be the same size, shape, and material although some packing companies are offering sets of alternately hard and soft or heavy and light rings. If the rings are all the same, only the top one or two are worn out when replacement is indicated and it may only be necessary to replace these. Under this procedure, it may be possible to avoid prolonged break-in and overheating. If, on the other hand, the rings are not all the same, the wear can take place on any one or more of the rings in the stack and it is necessary to replace the entire stack when excess leakage develops.

Where V-type packing is used, the gland serves only to keep the packing from shucking up and down in the box, since it is essentially self sealing. Square packing, on the other hand, is quite sensitive to gland adjustment and aside from positioning the packing in the box, the gland may be adjusted to get the desired amount of leakage as long as the packing is serviceable. Generally speaking, the problem is to provide a dense, resilient material that is insoluble in the liquid handled. Several materials fill this bill but unfortunately none of them have the all important low friction that is required for good plunger life. Lead, for example, is quite commonly used because of its high density, low friction and good resistance to erosion but it does not have any resilience. This means that it must constantly be adjusted or alternatively installed in combination with some more resilient material like rubber. Asbestos is probably the most commonly used material. Unfortunately, asbestos has a very high friction factor. For example, it is used in automotive brake lining and clutch facings. To offset this characteristic, braided asbestos is usually thoroughly impregnated with an oil and graphite mixture which ultimately washes out; therefore, this type of packing will be highly injurious to the plunger unless it is replaced when the lubricant is all gone.

The extent to which a box of square packing can be tightened is quite controversial. Certain packing manufacturers recommend that the gland be used only to get the initial "set" and from then on it is to be turned only enough to keep the packing snug against the bottom of the box. The discharge pressure working against the bottom of the packing stack will compress it tightly enough to effect a continuing seal.

Some sources recommend the technique of squeezing the packing whenever it leaks too much. This technique requires that a limit be set on how much the packing can be squeezed before it is considered worn out and in need of replacement. One solution it to advance the gland an amount equal to 20 percent of the stack height and then replace the packing. If the packing cannot be made to seal within this limited adjustment, both the packing and the plunger must be critically examined. A second solution is to continue adjusting the packing until it can no longer be made to seal. This system is widely employed; however, certain types of packing will severely damage the plunger if handled in this way.

When square packing stops sealing the flexibility is gone and it has become dense enough to score the plunger. *It is far cheaper to replace questionable packing than it is to make sure it is worn out and replace the plunger as a consequence!*

50,000,000 Lbs./Yr.

Industrial Alcohols Plant slated for Continental Oil Company

ALFOL facility to be Constructed at Lake Charles, Louisiana, Will be Completed Early in 1961

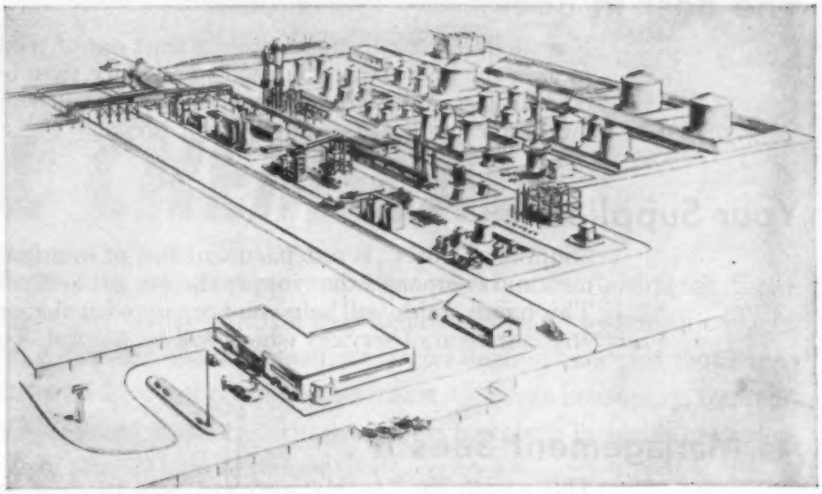
Continental Oil Company has announced that The Lummus Company has been awarded the contract to engineer and construct an Industrial Alcohols Plant at Lake Charles, Louisiana with a capacity of more than 50,000,000 lbs/yr.

These higher alcohols will be manufactured by a new technique originally conceived by Dr. Karl Ziegler. Organo-metallic catalysts are used to promote chain/growth of ethylene followed by oxidation and hydrolysis to primary straight-chain alcohols containing an even number of carbon atoms.

With completion of the plant these fatty alcohols will be available for the first time from petroleum rather than the natural sources such as tallow fat and coconut oil from which they are now produced. These primary alcohols to be marketed under the Conoco trade name of "ALFOL", will be used in the manufacture of detergents, plastics, cosmetics, lubricating oil additives, paper, textiles and emulsifiers.

The primary raw material, ethylene, for these new products will be obtained from the ethylene plant operated at Lake Charles by Petroleum Chemicals, Inc. of which Conoco owns a 50% interest. This plant was also engineered and constructed by Lummus.

In the past 50 years, Lummus has built over 800 plants to produce petrochemicals, chemicals and petroleum products. If your company is planning facilities of this kind, discuss your plans with Lummus.



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Valuable Reading Ahead

Here's a quick run-down on what's presented in this month's non-technical sections. These departments will keep you right up-to-date with what's new and different in this rapidly changing oil industry.

Olefins For England

In the lead story in this month's "Who's Building" section you'll learn about Imperial Chemical Industries' newest olefin plant at Wilton, England. This informative department will brief you on all the latest construction developments in your industry, from new units in the planning stage to those that have just come on stream. For comprehensive construction news from the oil, gas and petrochemical processing industries . . .

Keep going to Page 322

New Gimmicks

Somebody is always coming up with a new gimmick to save time and labor. And, people are interested in this, which accounts for the popularity of various "do it yourself" magazines. Well, PETROLEUM REFINER has its own version of do-it-yourselfism for the Industry. For example, this month you can learn how to use water pressure-drop data for easy solution of turbulent liquid flow problems. Simply . . .

Keep going to Page 312

The Best In Books

Knowledge is the key to success, at least one of them. And, what better way is there to gain the knowledge you need to advance than by reading a good book or report on a subject important in your industry. If you would like to learn about some of the better publications hot off the press . . .

Keep going to Page 347

Your Suppliers

"Suppliers Notes" is a department full of information you need to know about the men and companies that supply the oil, gas and petrochemical processing industry. This handy guide will help you keep up with the people who serve your plant, and any extension of services which will be helpful. To see for yourself . . .

Keep going to Page 407

As Management Sees It . . .

This month the "As Management Sees It . . ." section of PETROLEUM REFINER presents an article entitled, "Idea Acceleration—Key to Progress." Here you will learn that facts and timing are necessary for the birth of good ideas—and that one of the best "idea-reactors" today is the meeting. Of course, many meetings are a waste of time and energy, but properly handled they can produce chain reactions of creativity. You'll find this article interesting and informative, so be sure that you . . .

Keep going to Page 357

When it comes to

MINERAL ACIDS

SULFURIC ACID
Standard: 60° and 66° Baumé, 99% H_2SO_4
Diamond: 66° Baumé
Reagent, ACS

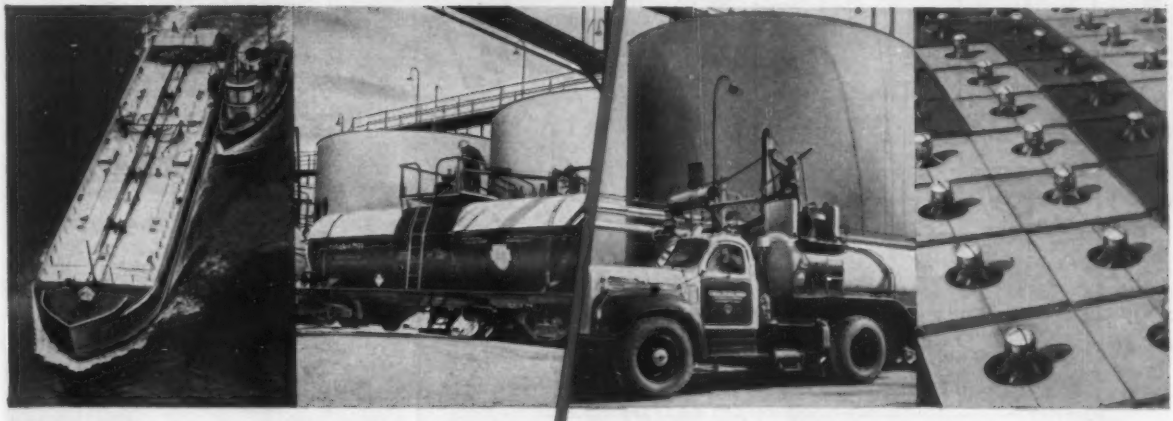
NITRIC ACID
Diamond: 36°, 38°, 40°, and 42° Baumé
Strong Nitric Acid, 95% and fuming grades
Photo-Engravers' Grade
Reagent, ACS

MURIATIC (Hydrochloric) ACID
18°, 20° and 22° Baumé, Standard, Diamond, Crystal and Reagent Grades

HYDROFLUORIC ACID
Anhydrous, Aqueous 70%, and Reagent

PHOSPHORIC ACID
Wet Process, 65% and 75%, Com'l and Fertilizer Grades
Food Grade, 75%
N.F., 85%

MIXED ACID
Varying proportions of Nitric and Sulfuric Acids to meet customers' requirements



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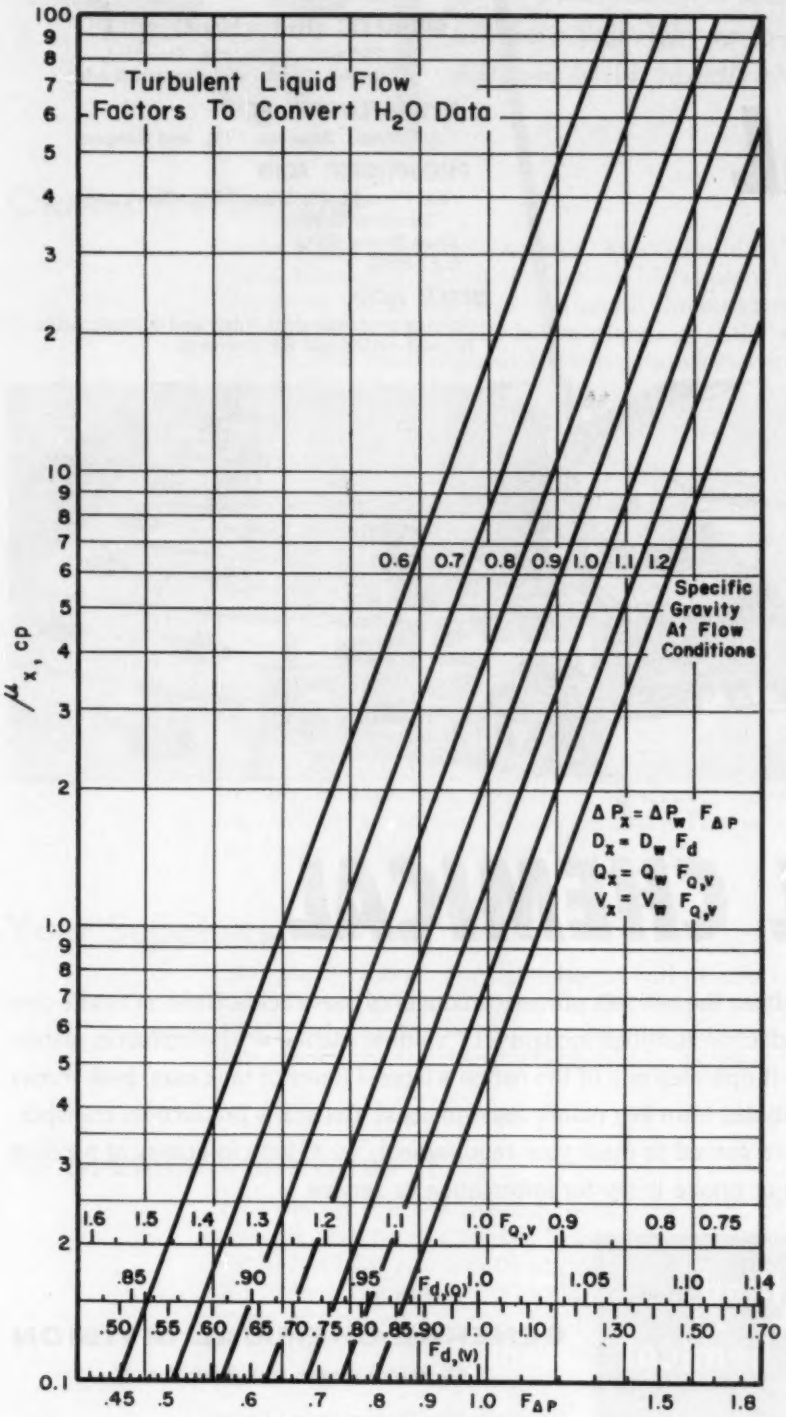
How to Do It...

Water Data Solve Fluid Flow Problems


Turbulent Liquid Flow
Factors To Convert H_2O Data
μ_x, cp
0.6 0.7 0.8 0.9 1.0 1.1 1.2
Specific Gravity At Flow Conditions
$\Delta P_x = \Delta P_w F_{\Delta P}$
$D_x = D_w F_d$
$Q_x = Q_w F_{Q,v}$
$V_x = V_w F_{Q,v}$
1.6 1.5 1.4 1.3 1.2 1.1 1.0 $F_{Q,v}$ 0.9 0.8 0.75
.85 .90 .95 $F_{d,(Q)}$ 1.0 1.05 1.10 1.14
.50 .55 .60 .65 .70 .75 .80 .85 .90 1.0 1.10 1.30 1.50 1.70
$F_{d,(V)}$
.45 .5 .6 .7 .8 .9 1.0 $F_{\Delta P}$ 1.5 1.8

B. Kouzel
Union Oil Co. of Calif.

IN TURBULENT liquid flow problems where any two of the variables, flow rate, pipe size, and pressure drop are known, a fast easy solution can be obtained. By assuming that the fluid is water at 60° F, using standard tabulated, water pressure-drop data and applying a multiplying factor, shown in the figure, the solution becomes one of simple arithmetic. This method eliminates the need for friction factor charts and trial-and-error calculations. And it gives results which are generally within 10 percent of those obtained by more rigorous procedures.

The multiplying factors used to correct the water data are functions of density and viscosity and can be derived starting with the Fanning equation

$$\frac{\Delta P}{L} \alpha \frac{fV^2\rho}{d} \alpha \frac{fQ^2\rho}{d^5}$$

where $\Delta P/L$ is pressure-drop in psi/100 ft, f is the friction factor, V is velocity in ft/sec, Q is flow rate in gal/min, and d is inside pipe diameter in inches.

The friction factor (f) can be approximated by the relation $f \alpha Re^{-n}$, where Re is the Reynolds number and n is 0.16.

The Fanning equation can then be written

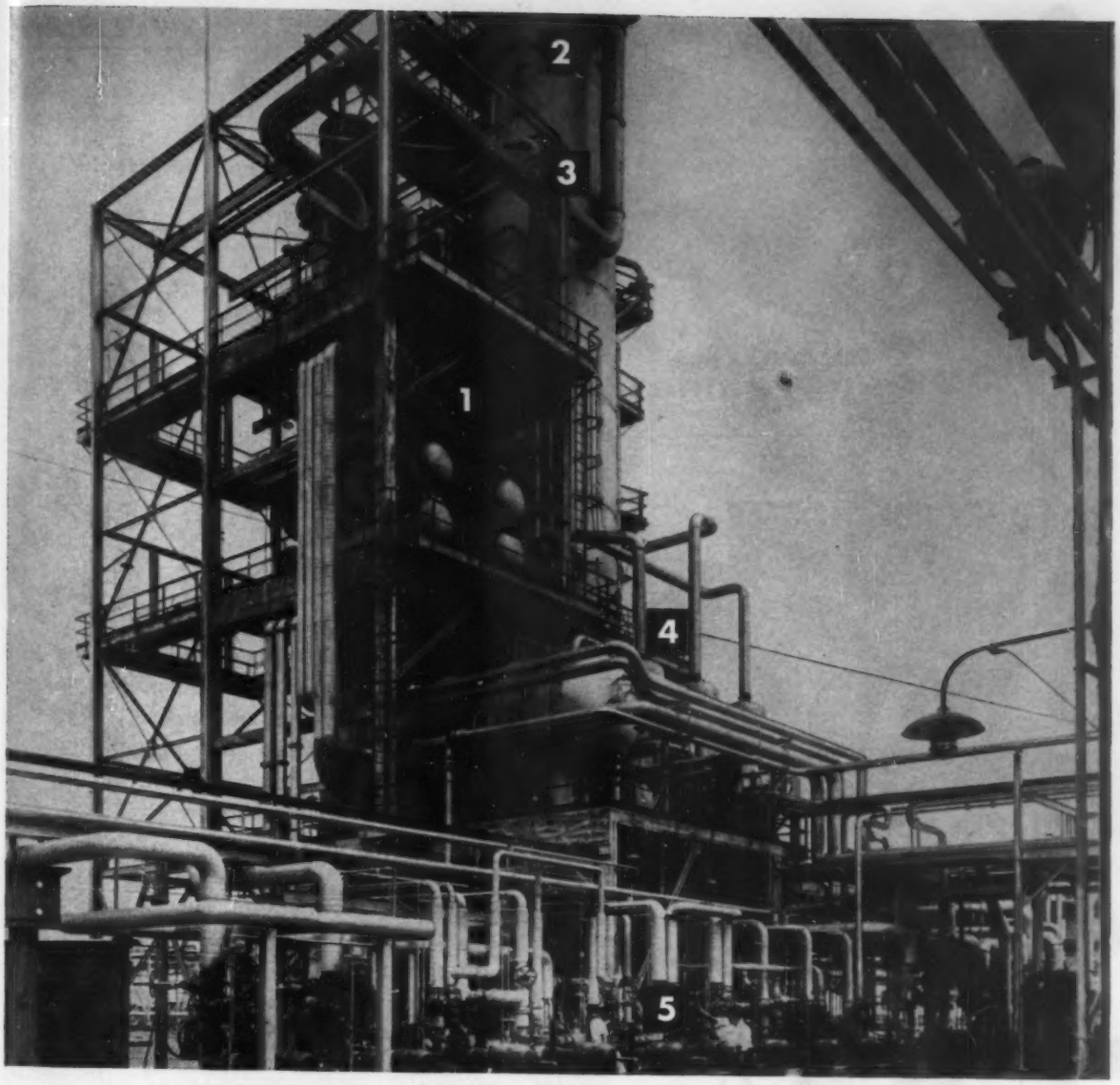
$$\frac{\Delta P}{L} \alpha \frac{V^{1.84}\rho^{.84}\mu^{.16}}{d^{1.16}} \alpha \frac{Q^{1.84}\rho^{.84}\mu^{.16}}{d^{4.84}}.$$

From the foregoing equation, the ratio of the pressure drop of any liquid to that of water at 60° F for the same conditions of flow rate and pipe size can be expressed as

$$\frac{(\Delta P/L)_x}{(\Delta P/L)_w} = \left(\frac{\rho_x}{\rho_w}\right)^{.84}\left(\frac{\mu_x}{\mu_w}\right)^{.16}$$

where subscripts x and w refer to any liquid and water, respectively.

The right-hand side of the equation is designated as $F_{\Delta P}$, the multiplying factor used to convert the water pressure-drop to that of the liquid being considered. Similarly, factors for velocity or flow rate at



5-point Monel "program" combats corrosion in Creole's 100,000 bbl crude unit

1. Atmospheric overhead condensers—Lukens Monel-clad steel on shell side.

2. Atmospheric tower – 20% Monel-clad on top head and top 11'6" of shell.

3. Atmospheric tower– top 4 trays of Monel alloy.

4. Distillate drum – 20% Monel-clad throughout, nozzles Monel lined.

5. Pumps handling naphtha product and reflux—shafts of "K"* Monel age-hardenable nickel-copper alloy; impeller, lantern and case wearing rings and packing gland of "H"* Monel semi-hard cast alloy; impeller wearing ring of "S"* Monel hard grade cast alloy; Duraseal of Monel alloy.

Creole Petroleum Corporation at Amuay Bay, Venezuela . . . and Foster Wheeler Corporation of New York City . . . took full advantage of the corrosion-resisting properties of Monel* nickel-copper alloys at five trouble-spots to combat corrosion . . . corrosion from dilute mineral acids, by sulfur and naphthenic contents of the feed.

Monel alloy resists corrosion by aqueous solutions of hydrogen sulfide and hydrochloric acid. Chloride traces, which can cause corrosion, and particularly at temperatures below 300°F, can be handled with Monel alloy. This high nickel alloy resists wet carbon dioxide, too.

How can Monel alloy fit in your refinery's program to combat corrosion?

Contact us for help with your corrosion problems. No obligation.

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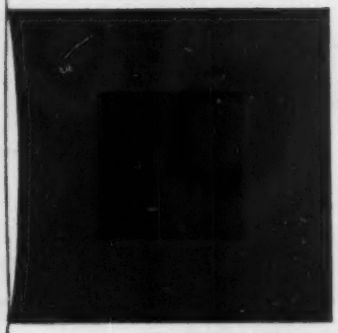
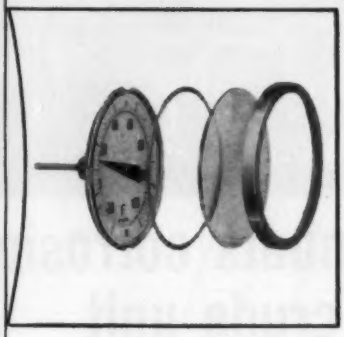
Weather-proof construction stymies erosion and corrosion





Complete protection against erosion and corrosion is built into American Bi-Metal Thermometers, so you can always be sure of accurate temperature measurement. Both case and bezel are stainless steel, precisely fitted and gasketed to insure snug mating. Whatever the weather, rain, sand, dust, dirt, fumes and frost are sealed out by a heat-resistant gasket between case and thick cover glass.

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American Bi-Metal Thermometer with weather-proof stainless steel construction.

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How To Do It . . .

constant $\Delta P/L$ and pipe diameter and pipe size at constant flow conditions and $\Delta P/L$ can be developed. These are tabulated below.

$$\text{At const. } \frac{\Delta P}{L}, d \frac{Q_x}{: Q_w} = \frac{V_x}{V_w} =$$

$$\left(\frac{\rho_w}{\rho_x}\right)^{.456} \left(\frac{\mu_w}{\mu_x}\right)^{.087} = F_{Q,V} = \frac{1}{F_{\Delta P}^{.184}}$$

$$\text{At const. } \frac{\Delta P}{L}, V \frac{d_x}{: d_w} =$$

$$\left(\frac{\rho_x}{\rho_w}\right)^{.722} \left(\frac{\mu_x}{\mu_w}\right)^{.138} = F_{d(V)} = F_{\Delta P}^{.361}$$

$$\text{At const. } \frac{\Delta P}{L}, Q \frac{d_x}{: d_w} =$$

$$\left(\frac{\rho_x}{\rho_w}\right)^{.173} \left(\frac{\mu_x}{\mu_w}\right)^{.033} = F_{d(Q)} = F_{\Delta P}^{.206}$$

It should be noted that all factors are functions of ρ and μ, and that $F_{Q,V}$, $F_{d(V)}$, and $F_{d(Q)}$ are related to $F_{\Delta P}$. For water at 60° F, the numerical value of 1.125 centipoises can be substituted for μ_w while the ratio ρ_x/ρ_w is proportional to the ratio of specific gravities with water having a value of 1.0. The factors, being power functions of viscosity and gravity, can be conveniently plotted on log paper. The figure shows the various factors on four horizontal scales plotted against liquid viscosity (centipoises) with parameters of liquid gravity (measured at flowing conditions).

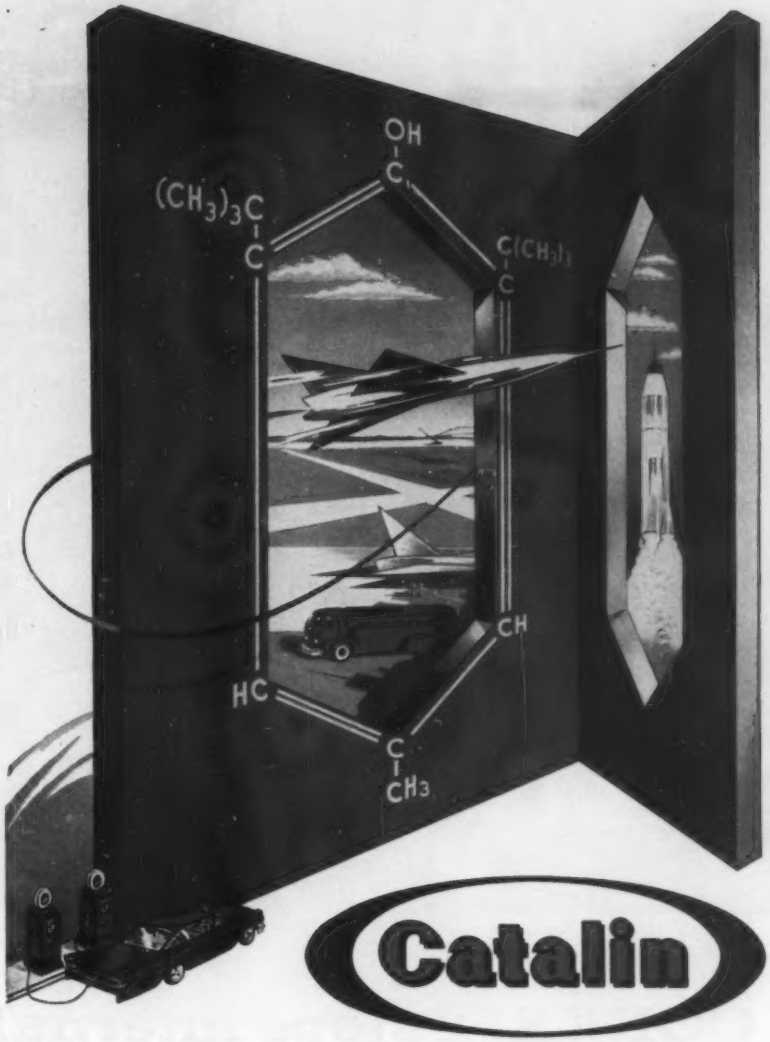
Before illustrating the use of the method, it should be noted that it will often be necessary to interpolate between data points in the pressure-drop table. For this purpose and in order to simplify calculations, the usual round-number relationships between variables may be used. That is:

For constant d: $\Delta P/L \propto Q^2 \propto V^2$

For constant Q: $d \propto \frac{1}{(\Delta P/L)^{1/5}}$

For constant V: $d \propto \frac{1}{(\Delta P/L)}$

Water pressure-drop data are generally given for Schedule 40, clean steel pipe. Solutions obtained for Schedule 40 pipe can be corrected to any other schedule number by means of the following relationships: (The symbols d_{40} and d_x refer to the I.D.'s



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Catalin ANTIOXIDANT CAO-1 . . . the field's finest grade of 2,6-ditertiary-butyl-para-cresol . . . meets U. S. Government military specifications for use in aviation gasolines, turbine and jet fuels. A major advantage achieved with this heat-resistant, water-insoluble antioxidant is that high-octane fuels are effectively protected, with no loss of octane rating. Gum and peroxide formations are inhibited, and deposits in the aircraft intake manifold and engine are markedly reduced.

Catalin ANTIOXIDANT CAO-1 stabilizes high-octane automotive gasolines, as well as turbine, insulating, hydraulic and transformer oils . . . in fact, nearly any petroleum hydrocarbon exposed to oxidizing conditions.

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chemicals plastics resins

* Typical Analysis

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COREXIT stops internal corrosion--reduces maintenance costs . . .

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HUMBLE OIL & REFINING COMPANY HUMBLE

How To Do It . . .

of Schedule 40 and any other schedule number.)

SCHEDULE 40 MULTIPLIERS

Answer To Be Corrected	Flow Variable Used In Calculations	Multiplier
$\Delta P/L$	Q	$(d_{40}/d_x)^{4.84}$
$\Delta P/L$	V	$(d_{40}/d_x)^{1.16}$
V	—	$(d_x/d_{40})^{.63}$
Q	—	$(d_x/d_{40})^{2.63}$

The following examples will be solved using the water pressure-drop data found in Crane Technical Paper No. 410 (Note: Other standard water pressure-drop data would give a similar result).

1. Solve for $\Delta P/L$ (flow rate and pipe size known).

Find $\Delta P/L$ when 420 gpm of hydrocarbon with a viscosity of 0.7 cp and a gravity of 0.75 flow through 6-inch Schedule 40 clean steel pipe.

From the water table, $\Delta P/L$ is 0.529 for 425 gpm flow in 6-inch pipe. Then $\Delta P/L$ for 420 gpm is $0.529\ (420/425)^2 = 0.517$ psi/100 foot. From the chart, for $\mu = .7$ and s.g. $= .75$, $F_{\Delta P} = 0.73$. Then, the required $\Delta P/L = 0.517 \times 0.73 = 0.376$ psi/100 foot.

2. Solve for d (velocity and $\Delta P/L$ known).

What size Schedule 40 pipe is needed to transport a fluid with a viscosity of 9.4 cp and a gravity of 0.895 at a velocity of 9.6 foot/second and an allowable $\Delta P/L$ of 9.9 psi/100 foot?

From the water table it can be seen that the pipe size for water flowing at these conditions will be between 1½ and 2-inch. For 1½-inch pipe, $\Delta P/L$ is 10.21 at 9.47 foot/second. Then for 1½-inch pipe at 9.6 foot/second, $\Delta P/L = 10.21\ (9.6/9.47)^2 = 10.5$ psi/100 foot. The interpolated pipe I.D. to give the specified $\Delta P/L$ of 9.9 at 9.6 foot/second is: $(10.5/9.9)\ (1.610) = 1.71$ inch I.D. (the I.D. of 1½-inch Schedule 40 pipe is 1.610).

From the chart, at $\mu = 9.4$ and s.g. $= .895$, $F_{d(V)} = 1.24$.

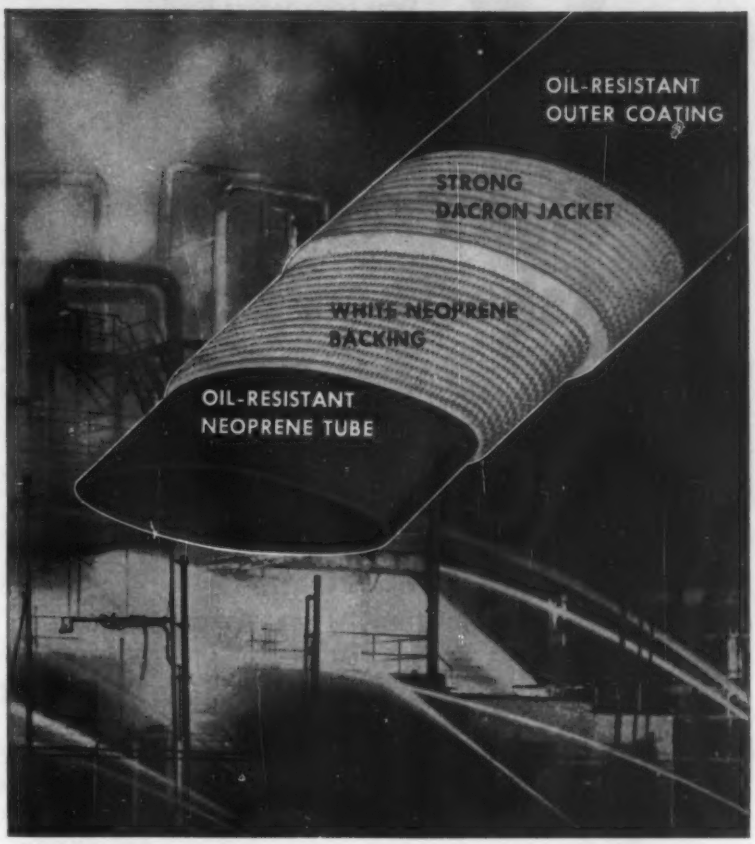
Then the required pipe I.D. $= 1.71 \times 1.24 = 2.11$. Use 2-inch pipe.

3. Solve for d (flow rate and $\Delta P/L$ known).

What size Schedule 30 pipe is needed to transport a fluid having a viscosity of 12.5 cp and gravity of 0.87 at a rate of 1330 gpm and allowable $\Delta P/L$ of 0.2 psi/100 foot?

From the water table it can be

YEARS OF CHEMICAL EXPOSURE CAN'T KNOCK OUT THIS PETROCHEM FIRE HOSE



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Many large chemical plants (typical case histories on request) report PETROCHEM hose still going strong after as long as *four years'* constant exposure to sulfur, chlorine, solvents, etc., where hose previously had to be replaced two or three times a year.

Neoprene inner tube and neoprene-impregnated "Dacron" jacket give PETROCHEM maximum corrosion-resistance. *And PETROCHEM is the only all-synthetic fire hose with UL approval.*

Ask the Thermoid industrial distributor about PETROCHEM "White" and PETROCHEM "Black" fire hose to meet the severest requirements of the oil and chemical industries. Or write *Thermoid Division, H. K. Porter Company, Inc., Tacony & Comly Sts., Philadelphia 24, Pa.*

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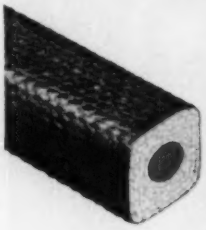
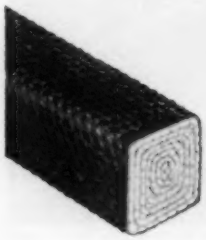


Solid, hollow center, metal center, rubber center and rubber-backed, woven and braided asbestos types for severe service against wet and dry steam, air, gases, and hot oil at temperatures up to 600° F, on piston rods, valve rods, valve stems, expansion joints, compressors, etc.



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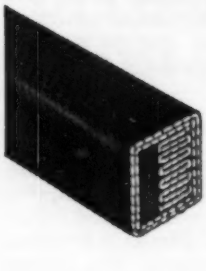

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The Belmont Packing and Rubber Company
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How To Do It . . .

seen that the pipe size for water flowing at these conditions will be between 10 and 12 inch. For 10-inch pipe, $\Delta P/L$ is 0.355 at 1300 gpm. Then for 10-inch pipe at 1330 gpm, $\Delta P/L = 0.355\ (1330/1300)^2 = 0.372$ psi/100 ft. The interpolated pipe I.D. to give the specified $\Delta P/L$ of 0.2 at 1330 gpm is: $10.02\ (.372/.2)^{1/5} = 11.35$ inch I.D.

From the chart at $\mu = 12.5$ and s.g. $= .87$, $F_{d(Q)} = 1.057$.

The required pipe I.D. $= 11.35 \times 1.057 = 12.0$. Use 12-inch.

4. Solve for Q (pipe size and $\Delta P/L$ known).

What will be the flow rate of a fluid with a viscosity of 0.88 cp and s.g. of 1.0 in a 1½-inch Schedule 40 pipe if the allowable $\Delta P/L$ is 3 psi/100 foot?

From the water table, for 1½-inch pipe the flow will be between 30 and 35 gpm. The data show 2.72 psi/100 foot for 30 gpm. Then for 3 psi/100 foot, the flow rate is $30\ (3.0/2.72)^{1/2} = 31.5$ gpm. From the chart at $\mu = .88$ and s.g. $= 1$, $F_{Q,\,v} = 1.02$. Then the required flow $= 31.5 \times 1.02 = 32.2$ gpm.

5. Solve for V (pipe size and $\Delta P/L$ known).

Given the same conditions as Problem 4, find the flow velocity. From the water table, for 1½-inch pipe the $\Delta P/L$ is 3.64 at a velocity of 5.52 foot/second. Then for 3 psi/100 foot, the velocity is $5.52\ (3.0/3.64)^{1/2} = 5.0$ foot/second.

From the chart at $\mu = .88$ and s.g. $= 1.0$, $F_{Q,\,v} = 1.02$. Then the required velocity $= 5.0 \times 1.02 = 5.1$ foot/second.

YOUR IDEAS ARE VALUABLE!

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

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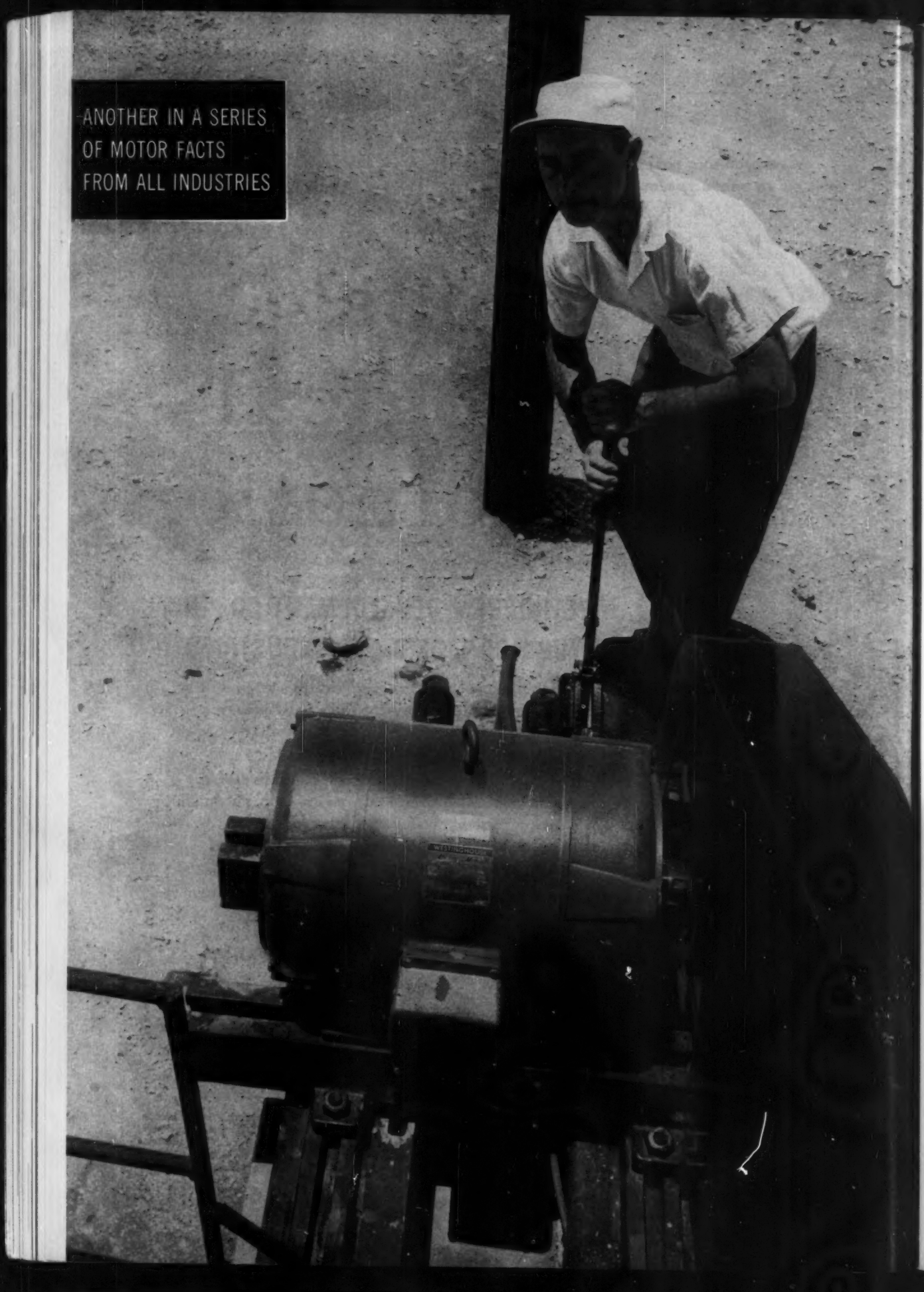
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Nothing stops These Westinghouse Life-Line A Motors

dependably driving oil well pumps in Odessa, Texas district of The Atlantic Refining Company, 24 hours per day, 7 days a week!

"Here's an application," says A. P. Johnston, production engineer at The Atlantic Refining Company, "where we must have continuous motor operation . . . sometimes for as long as 18 months . . . with virtually no maintenance or repair. Many of our pumping stations are remotely located, automatic and unmanned. Any stoppage or motor failure would result in the loss of several hundred barrels of oil. Motor repairs in the field are prohibitive in cost. We must have *complete* motor reliability and that's exactly what we get from our Westinghouse Life-Line® "A" motors."

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J-22055-R

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On this pumping unit, the 15-hp Life-Line "A" motor operates in an atmosphere of damaging dust, sand and moisture. Despite continuous, heavy-duty service, motor has never suffered any overheating since first installed. Prelubricated bearings of the Life-Line "A" eliminate periodic greasing . . . keep lubricant in . . . dirt out.

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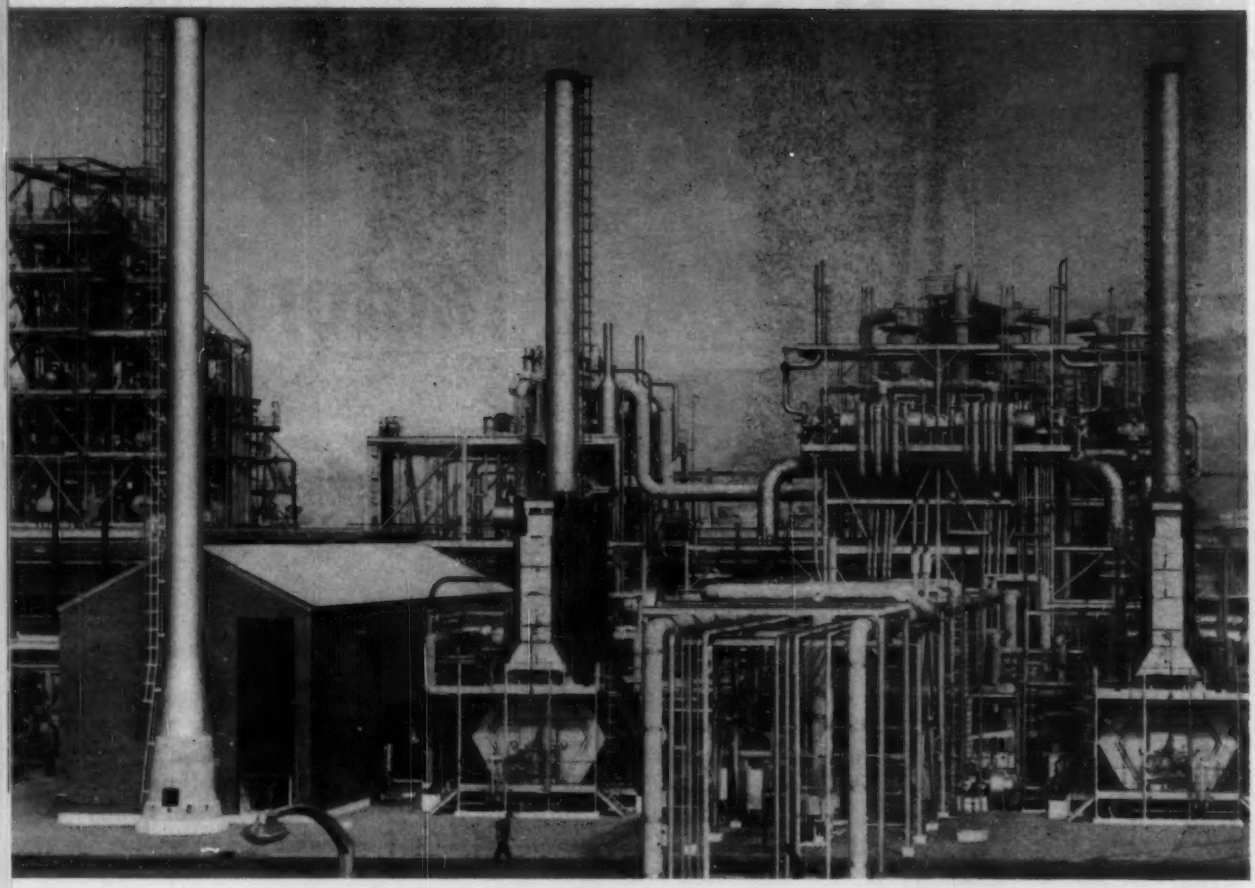

Wilton, England, plant produces 110,000 tons per year of high-purity ethylene.

England Gets More Olefin Capacity

ICI's third olefin plant ups company's total capacity by 60 percent. Another increase coming

THE THIRD olefin plant of Imperial Chemical Industries, Ltd.'s Heavy Organic Chemicals Division has been completed and placed in operation at Wilton, North Yorkshire, England, raising the company's total olefin capacity by 60 percent.

Capacity. Output of the chief product, high purity ethylene, is about 110,000 tons a year. Plans are under consideration for increasing this to 140,000 tons a year by additions to and modifications of this and the two other ICI olefin plants at Wilton.

The new unit uses essentially the same processes as previously constructed plants but is much larger. There is a pyrolysis section which converts or cracks the petroleum feedstock into a mixture of gases and crude gasoline and this is followed by the product separation and purification section. Thus, the three plants are at present consuming between 550,000 and 600,000 tons a year of light naphtha.

Plant Description. Naphtha feedstock is delivered by tankers to stor-

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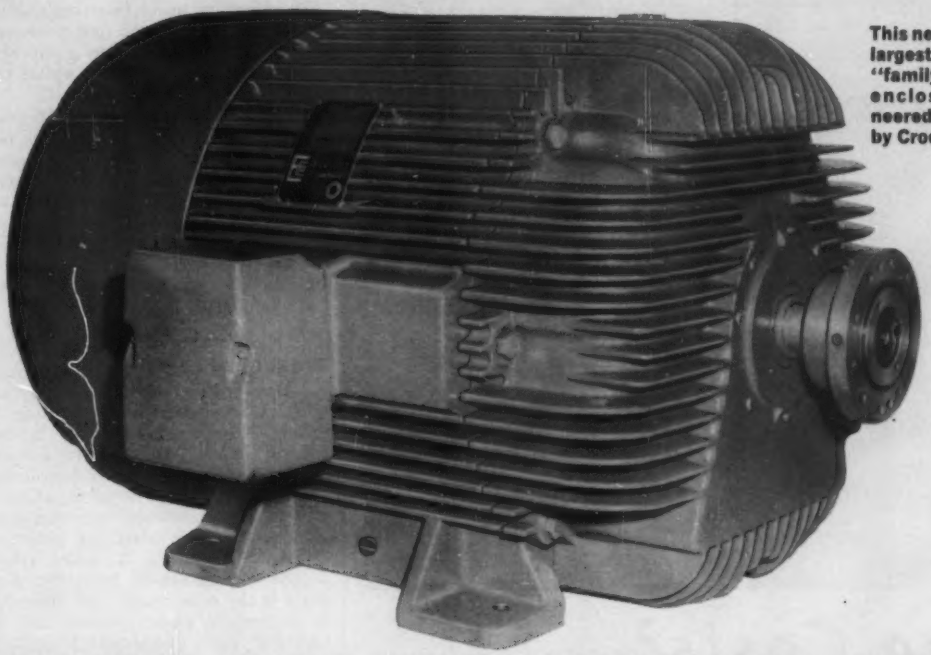


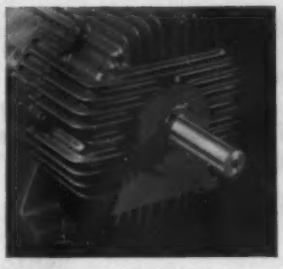
This new 300-hp unit is the largest of the Elliott C-W "family" of ribbed-frame enclosed motors, pioneered in the United States by Crocker-Wheeler.

ELLIOTT C-W SEALEDPOWER MOTORS

The numerous thin, deep ribs of Elliott C-W SEALEDPOWER Motors are the most advanced development of the ribbed construction, pioneered in the United States by Crocker-Wheeler. Modifications of SEALEDPOWER totally-enclosed fan-cooled motors include explosion-proof designs in all ratings up to 300 hp. Either open greasable or pre-lubricated bearings can be furnished.

Highly-effective sealing prevents entrance of moisture, dust, dirt, corrosive materials; consequently these motors can be depended upon for long, trouble-free service.

In numerous cases, SEALEDPOWER motors are proving to be more economical than standard open motors because of their low maintenance and dependability.



Extra fins keep bearing cool. This potential trouble spot is effectively cooled by the generous extra fins seen in the photograph above.

Cooling blast hugs frame. Air is directed along fins extending entire motor length. Easy to clean — no enclosed cooling passages to clog up.

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Newest data on modern enclosed motors—including explosion-proof—is given in Elliott Bulletin PB 6000-2. Send for free copy today.

W9-2

age at the plant. From there it is supplied to the pyrolysis sections of the three olefin plants.

The pyrolysis section of No. 3 olefin plant consists of three independent parallel systems, each with its separate tubular oil heater, tubular steam superheater, soaker line and quench boiler. In the latter, 250 psig steam is generated as the reaction is quenched. The independence of each system provides valuable flexibility in regulating pyrolysis conditions at different rates of naphtha feed.

The products of pyrolysis then enter the primary fractionator where the small amount of heavy polymeric oil is separated from the gas and gasoline and used subsequently as fuel oil. The steam is also condensed at this stage and separated.

The gas and gasoline proceed to the gas separation section. This is sub-divided into a compression unit for process gas and refrigeration purposes; a purification unit where hydrogen sulphide, water, and acetylene are removed from compressed process gas; a warm fractionation system where gasoline and butylenes plus butadiene are separated; and finally a train of fractionating columns operating at low temperature in which the remaining light hydrocarbon products are separated.

Gas Generators. The most novel engineering feature of the plant is perhaps the battery of free-piston gas generators and their associated gas expansion turbines and centrifugal compressors contained in the compression unit.

The free piston gas generator is, as its name implies, an engine that generates hot gas (660° F) at 45 psig. The energy in this gas is expanded in gas expansion turbines to produce shaft power. Basically, the generator is an opposed piston two-stroke diesel cylinder, highly super-charged (50 psig) which exhausts to a pressure of 40-45 psig. This exhaust is the 'gas' which is fed to turbines for conversion into shaft power. The object of using this combination of power generators and compressors was to provide a compression plant of high efficiency at a reasonable capital cost.

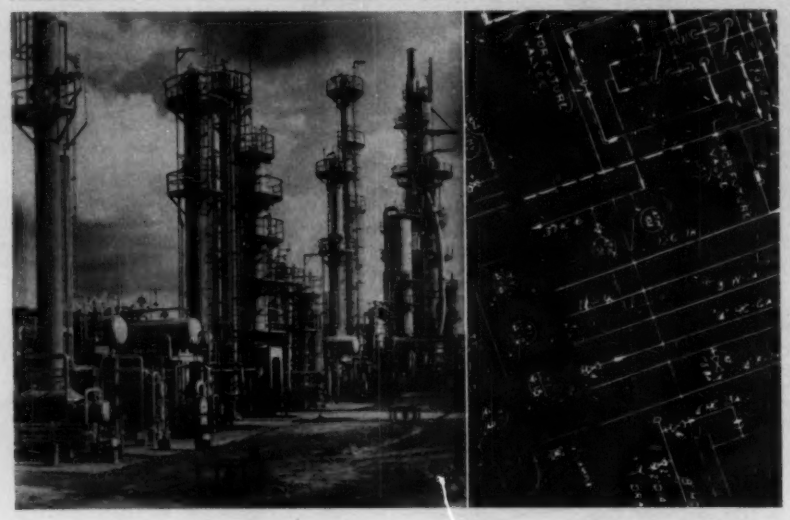
Gas Purification. The purification of compressed gas for this plant is on the same general lines as for its predecessors. Hydrogen sulfide is removed by caustic soda scrubbing, the water content of the gas is reduced to less than 0.014 grains per cubic foot in gas driers employing activated alumina desiccant, and a small non-commercial quantity of acetylene is removed by hydrogenation over a catalyst.

Product Streams. The warm fractionation unit produces butylenes/butadiene and crude debutanized gasoline. The butylenes/butadiene stream is caustic washed before transfer to consuming plants, and the gasoline is transferred to the gasoline treatment plant where it is treated in combination with the gasoline streams from the other two plants.

Separation of the methane, ethylene, propylene and ethane from the purified gases is the most costly and difficult step in the whole plant process, and many variants were considered before the actual process was decided. As in the other two olefin plants, separation is achieved by low temperature refrigeration and fractional distillation under medium pressures, but certain modifications are incorporated. For the third plant, refrigeration is provided by a propylene compression system and by a two-stage ethylene compression system in cascade with it. Finally, in order to reach the lowest temperature required for separation of methane and lighter gas, instead of a further stage of refrigeration compression, the methane product is reduced in pressure and evaporated.

Automatic Control. Although 150 persons are employed over-all, No. 3 olefin plant itself is operated on four shifts of 13 people. Numbers are governed more by strict considerations of safety than for operational necessity, but even so, an extremely high tonnage output per man is achieved.

In the three olefin plants, there are altogether 36 continuous and fully automatic analysis instruments transmitting their readings to recorders in the control rooms. Non-dispersive infra-red spectrometers are used extensively for analysis of simple mixtures of light hydrocarbons. For more complex composi-



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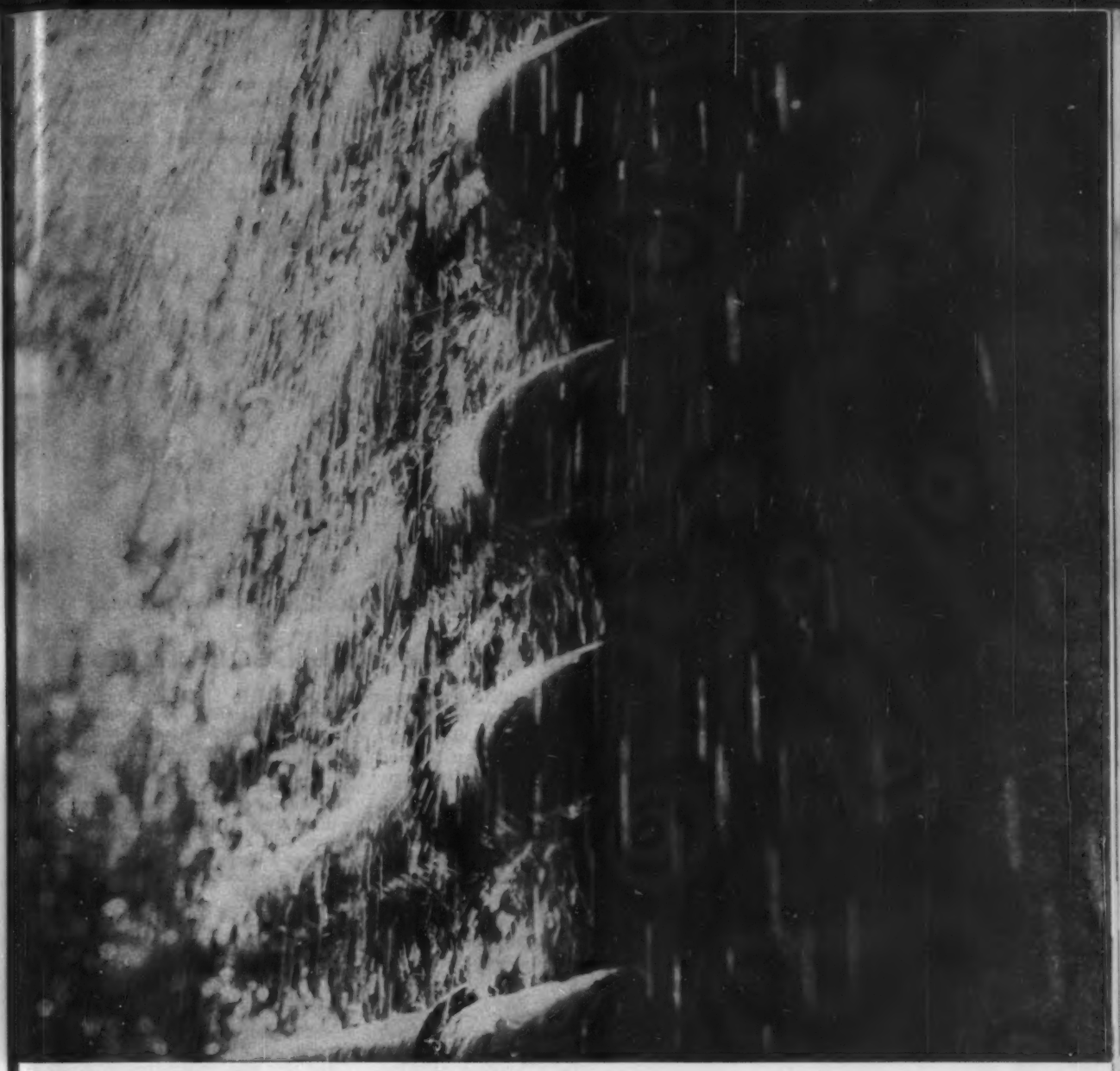

Stainless Steel pipes cool hot acid

AT SINCLAIR REFINING COMPANY, HOUSTON, TEXAS

This continuous SO_3 sulfonization unit produces a high detergent lube oil additive. The picture shows Type 316 Stainless Steel pipes in the cooler. 98% sulfuric acid enters the coils at about 145°F and is cooled to 105°F by water.

The pipes take punishment three ways: high temperature, acid corrosion, and erosion. At first, some of the pipes were made of a less resistant metal but they had to be replaced with Stainless Steel after only eight months. There has not been one sign of deterioration in the replacements or in the Stainless Steel pipes installed originally.

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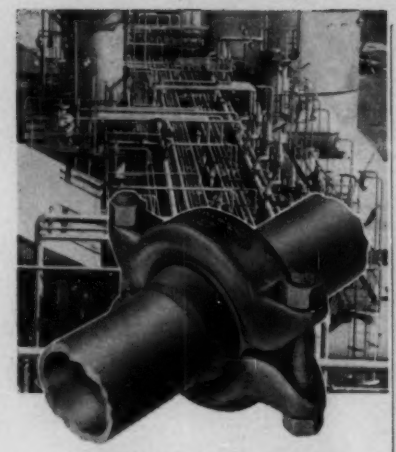

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The bolting carries no primary force from internal pressures. Two bolts serve only to pull the connection together through the wedging action of the clamp and the seal ring.

Flexible tapered lips of the seal ring are angled slightly less than the mating hub. This forms a line seal which is changed to a surface seal as the connection comes together and the lips deflect.

GRAYLOC has practical uses in any application where flanges are used. GRAYLOC is recommended where pressures are high or where you want savings in money, space, weight or time.

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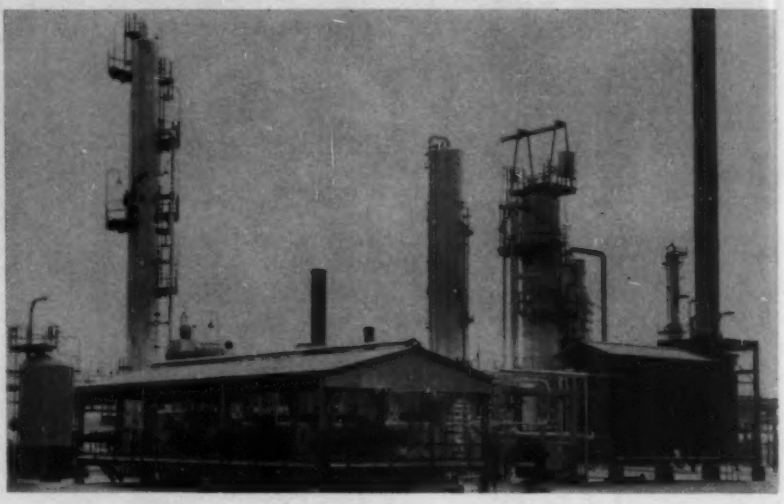
Building . . .

tions and low concentrations, a chromatograph or an instrument employing chemical analysis is used. In addition to automatic analyzers, a large staff works in the laboratory on analysis concerned with control of the unit and the checking of product purities. Here again, full use is made of modern instruments.



B-A Completes Distillate Desulfurizer

A new 8,000-bpd distillate desulfurization unit has gone on stream at The British American Oil Co., Ltd.'s Clarkson, Ont., refinery. Canadian Kellogg, Ltd., Toronto, was contractor for design, engineering, procurement, and construction. The unit is designed to remove 90 percent of the sulfur content in three charge stocks: fluid catalytic cracking light-cycle oil, stove and diesel base. It will be run in blocked operation with intermediate storage. Hydrogen will be supplied from reformer gas and a pelletized cobalt moly catalyst will be used. This unit has been designed so capacity can be doubled with minimum changes. The addition of a second reactor equipped with its own separator and fractionator system will enable the unit to handle either two distinct feedstocks or double any one feedstock.

British American Oil Co. has completed Stage III of its gas processing and sulfur plant near Pincher Creek, Alba., ahead of schedule, enabling the plant to meet planned increases in contract demands of the Trans-Canada Pipe Line.

The $4-million expansion of processing facilities at the $25-million plant has boosted raw gas throughput. Based on a raw gas feed rate of 196 Mmcf per day, the plant would recover daily 145 MMcf of residue gas, 24,500 gallons of propane, 31,400 gallons of butane, 5,300 barrels of condensate and 690 long tons of sulfur.

The plant was built in three stages, first of which commenced operation in January 1957. Stage I was a recycling operation with a raw gas throughput capacity of 60 MMcf per day. It removed surfur and condensate from the wet gas which was re-injected underground for storage.

Stage II, completed last Fall, raised raw gas throughput capacity to 120 MMcf per day and made possible production of propane and butane. It also increased condensate capacity and boosted sulfur production from 225 to 425 long tons daily.

Montecatini Co. has completed a new 30,000-metric-ton-per-year ethylene plant at Ferrara, Italy, engineered by The M. W. Kellogg Co. and Kellogg International Corp. It is Montecatini's second ethylene plant in Ferrara, the first having gone on stream in 1955.

The new plant is designed to produce high-purity ethylene products (95 to 99.85 percent purity) and 15,000 metric tons per year of high purity propylene product from the pyrolysis of light or heavy naphtha.

The unit will also produce low-purity propylene, propylene-propane product, B-B product, C_5 product, gasoline product, and quench oil product from which gasoline, gas oil and fuel oil are recovered.

The pyrolysis section of the plant is specially designed to provide gum-free operation. Each of the three parallel pyrolysis systems consists of a charge pump, naphtha preheat furnace, flash drum and pyrolysis furnace in addition to the steam and quench equipment. Separate lines from battery limits are provided to permit charging either light or heavy naphtha to any pyrolysis system. The addition of naphtha preheat furnaces permits use of low pressure steam in the pyrolysis furnace and re-

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repeat business . . . 3 MAJOR EXPANSIONS AWARDED TO BROWN & ROOT

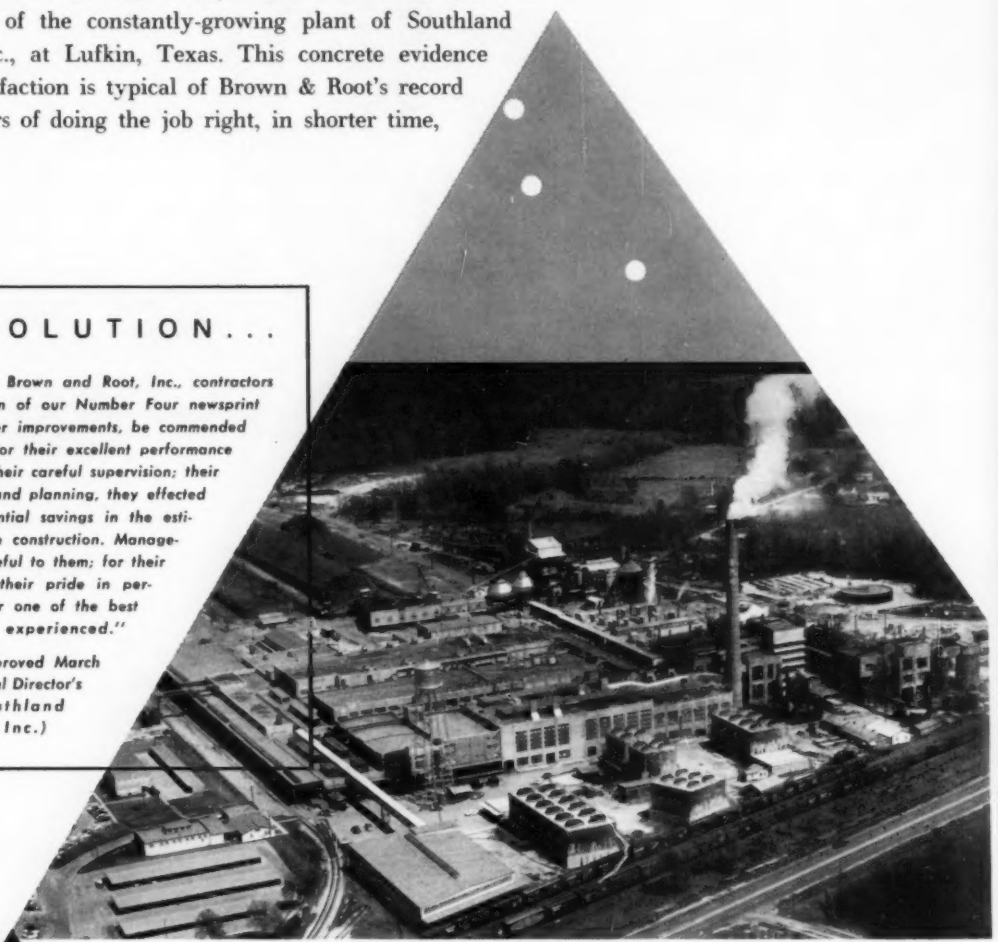
in eleven years

In 1946, and again in 1955 and 1957, Brown & Root was called in for construction of the constantly-growing plant of Southland Paper Mills, Inc., at Lufkin, Texas. This concrete evidence of customer satisfaction is typical of Brown & Root's record through the years of doing the job right, in shorter time, at lower costs.

A RESOLUTION . . .

"RESOLVED, That Brown and Root, Inc., contractors for the installation of our Number Four newsprint machine and other improvements, be commended by Management for their excellent performance rendered us. By their careful supervision; their fine engineering and planning, they effected us a very substantial savings in the estimated cost of the construction. Management is very grateful to them; for their cooperation, for their pride in performance, and for one of the best jobs we have experienced."

(Unanimously approved March 31, 1959 at annual Director's Meeting of Southland Paper Mills, Inc.)



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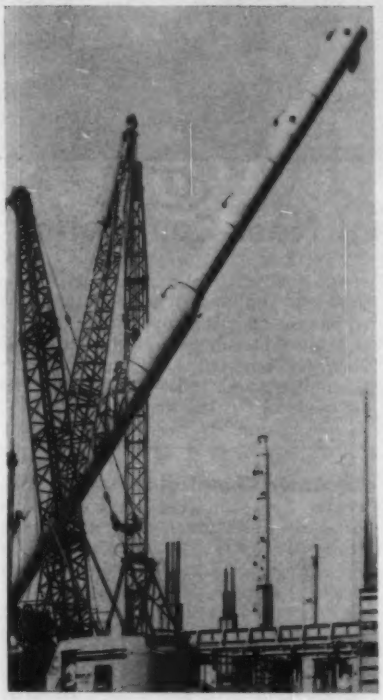
duces gum formation in the furnace vaporization zones.

Downstream from the pyrolysis section are provisions for compression and hot fractionation, caustic scrubbing, drying, acetylene removal, cold fractionation, ethylene refrigeration, and propylene refrigeration.

New Acrylonitrile Plant For Sohio Chemical Co.

Construction of Sohio Chemical Co.'s new acrylonitrile plant, Lima, Ohio, is nearly half completed and is on schedule. First product test runs for the plant are



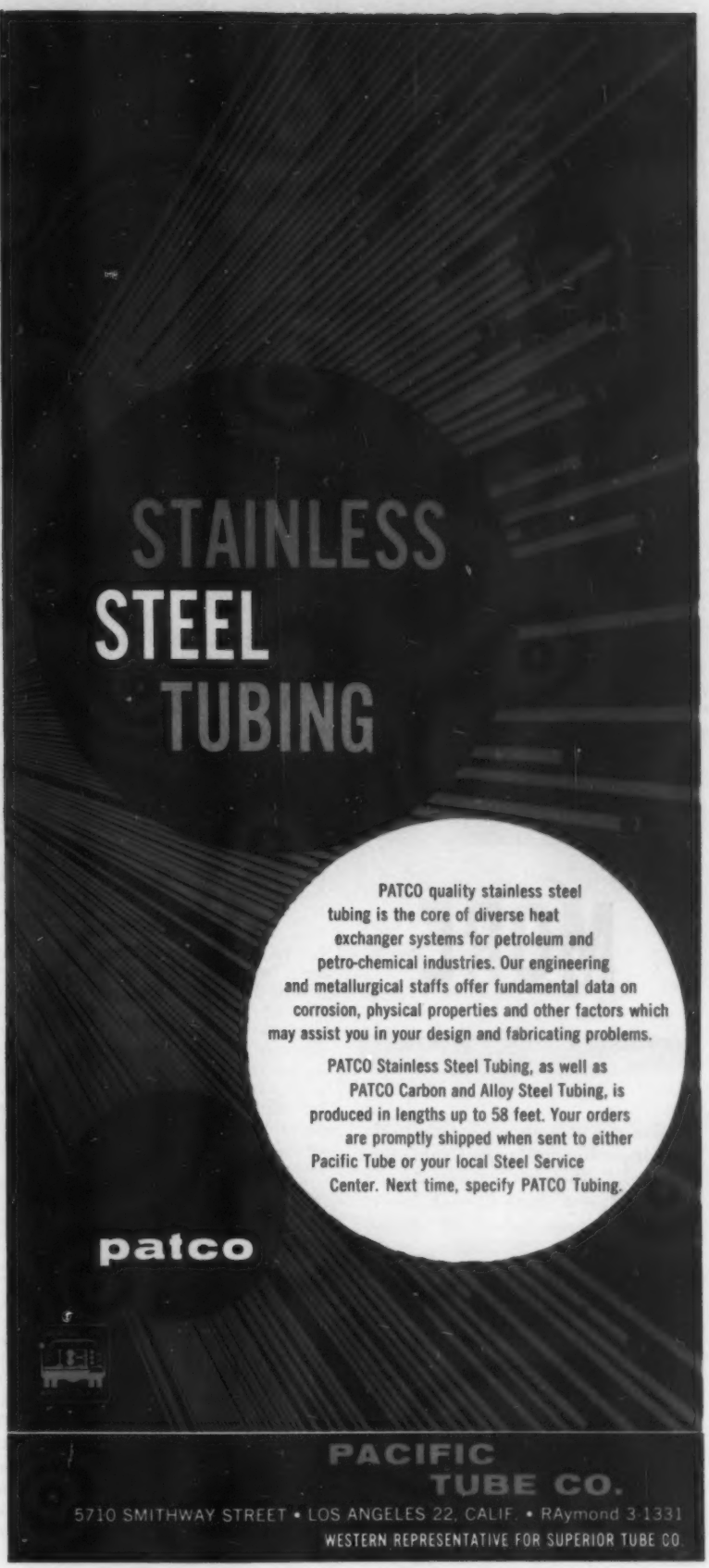
expected in early 1960. The facility will use a process employing single-step direct conversion of refinery propylene and anhydrous ammonia. The picture shows the raising of one of the tallest columns to be installed at the Lima plant.

Texaco, Inc., has begun an $18-million expansion program to make its Pointe-a-Pierre, Trinidad, refinery one of the world's largest and most modern oil processing plants.

Construction of new units will increase to 235,000 bpd the crude oil capacity of the company's largest Caribbean refinery. Present throughput is about 135,000 bpd.

New units will be adjacent and complementary to the existing refinery, and will consist of a 100,000-bpd topping unit, a 15,000-bpd catalytic reformer and a 20,000-bpd hydrotreater. Also to be added are new tankage, pipelines, utilities and jetty facilities.

Site clearance has been completed and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PATCO Stainless Steel Tubing, as well as PATCO Carbon and Alloy Steel Tubing, is produced in lengths up to 58 feet. Your orders are promptly shipped when sent to either Pacific Tube or your local Steel Service Center. Next time, specify PATCO Tubing.
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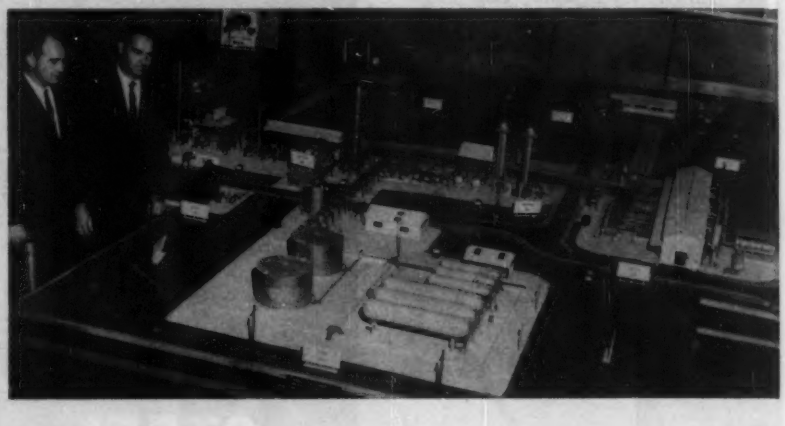
Building . . .

foundations are laid. Construction, expected to take 12 months, will be handled by Caribbean Bechtel, Ltd.

Engineering design for the three refining units was done by Fluor Engineering and Construction Co., Ltd. Process design for the hydrotreater was done by Texaco's Engineering Department. Design for the three refining units was done by Fluor Engineering and Construction Co., Ltd. Process design for the hydrotreater was done by Texaco's Engineering Department and for the catalytic reformer by Universal Oil Products, Inc.



Weeks Island Gas Plant Near Completion

This ¼-inch scale model of Shell Oil Co.'s gas cycling and processing plant currently near completion at Weeks Island, Iberia Parish, La., was one of the exhibits at the Louisiana Gulf Coast Oil Exposition October 8-11 in Lafayette. The model was built to assist the contractor in preparing construction drawings and to aid in the training of employees in plant operations. At left is Murray Cunningham, chairman of the New Orleans Oil Centennial Exhibits Committee, and J. D. Thompson, project engineer for the plant.

Novamont Corp. plans to more than double production capacity of its Neal, W. Va., polypropylene plant to 25 million pounds annually. The Montecatini Co. subsidiary reports that plant designs have been revised to accommodate the new production figures, but the planned increase reportedly will not delay the start of construction, scheduled to begin this month. The plant, slated to go on stream early in 1961, will be situated on a 200-acre tract on the Big Sandy River. In addition to polypropylene, it will produce other polyolefins important in the manufacture of plastics, textile fibers and yarns and elastomers.

In the original announcement of the Neal plant, which is Montecatini's first American industrial venture, plant capacity was set at slightly more than 11 million pounds.

Foster Grant Co. is planning a $4-million expansion of its operations at Leominster, Mass. The new facilities, which will undergo construction next year, will produce plastic polymers and copolymers, styrene monomer and molded plastics. Included in the program will be additions to present facilities at Leominster and Baton Rouge, and a new research and development laboratory. Also included are a pilot system for production of various thermoplastic products, as well as the purchase of additional equipment.

Furukawa Chemical Industries Co., Tokyo, has completed what it says is the world's first commercial plant to use the Standard Oil Co. (Indiana) process for making polyethylene and copolymer plastic. Using low pressure, it will have a capacity of 20 million pounds per year when regular commercial operations are under way.

Standard Oil, in addition to licensing its process, also prepared the basic process design for the plant, which was completed in less than a year. The plant was designed to make both high-density polyethylene and copolymers.

In the Standard process, a wide range of plastics can be made in a single plant. These range in density from typical rigid polyethylene to copolymers having a density comparable to conventional high-pressure polyethylene.

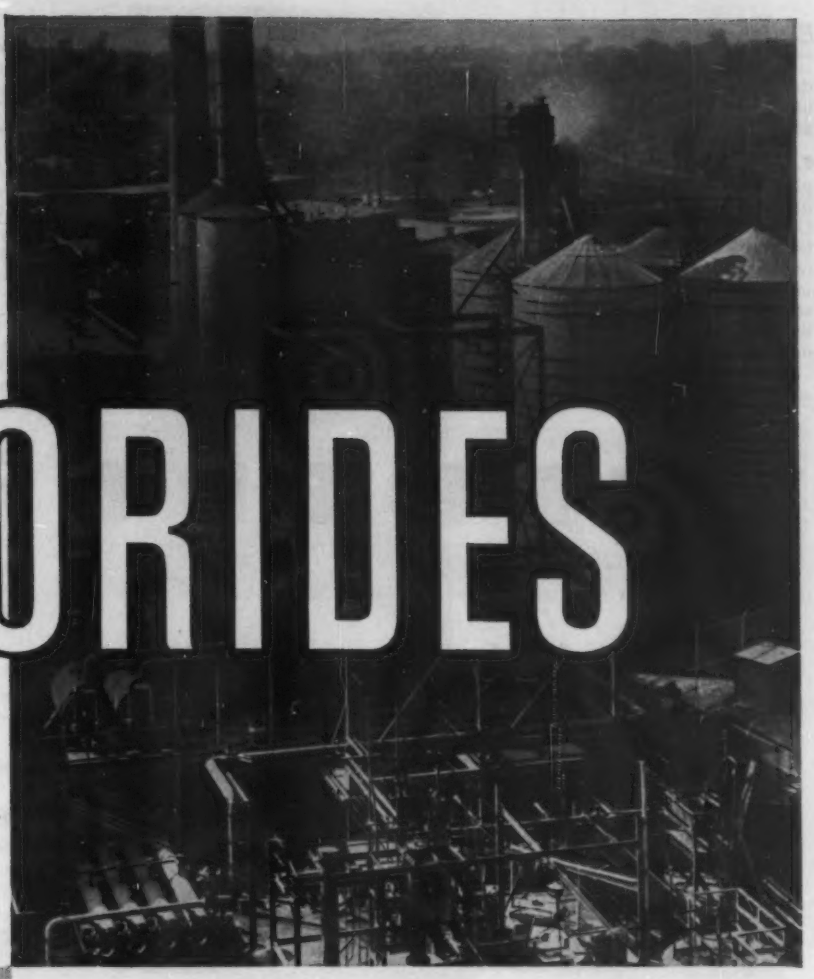
Alba, S.A. has installed near Cubato, Brazil, what it says is the first synthetic methanol plant in South America to utilize the Inventa-Vulcan process. The 30-ton-per-day plant produces 99.95 percent methanol, which is used in the production of formaldehyde.

Engineering and procurement for the new unit was supplied by Vulcan-Cincinnati, Inc., who reports that the plant went on stream two weeks after construction was completed.

The Alba methanol plant is the second in the Western Hemisphere to employ

HARSHAW

FLUORIDES



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ANOTHER FIRST FOR HARSHAW

Harshaw's newest fluoride is silicon tetrafluoride. One of the major oil companies has just developed a process for sealing water out of oil wells during drilling with this newly introduced fluoride.

In 1904 when The Harshaw Chemical Co. first started to manufacture hydrofluoric acid, all of the production was used by foundries to remove sand from iron castings. Today, Harshaw's fluoride division produces 26 different fluoride chemicals for as many industries.

The major uses of Harshaw Fluorides are in the petroleum, glass, steel, and atomic energy industries. Even in these industries the uses are diversified. The versatility of Harshaw fluorides is also evident by their use in soldering fluxes, cleaning boilers, removing iron stains and souring laundry, curing plastics, alloying aluminum, floating minerals, sanitizing breweries, and treating water.

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Building . . .

the Inventa-Vulcan process. The first, built for Hercules Power Co. at Louisiana, Mo., went on stream in late 1957.

E. I. duPont de Nemours & Co. plans to build another acrylonitrile plant, its second this year, at Beaumont, Texas. Construction, to begin immediately, will be handled by the company's Engineering Department, and start up is expected in Spring 1961. Du Pont will use a recently patented process involving synthesis from ammonia and propylene, a method worked out by the company's Central Research Department.

Esso Standard Oil Co. has started construction of new asphalt pipe still at its Bayonne, N. J., refinery. Slated to come on stream in Spring 1960, the unit will be equipped much like the company's present "B" unit. It will have two fractionating towers and two furnaces. New heat exchangers and coolers as well as new pumps and a control room will be installed to replace existing ones.

The unit will include valve-type trays for the vacuum and atmospheric towers. Replacing the existing bell-cap trays, the valve trays will be the first ever used in an Esso crude distillation unit. They are designed to operate more efficiently over a wider range feed rate.

The Consolidated Mining and Smelting Co. of Canada, Ltd., has completed plans for a 100-ton-per-day urea plant to be built at Calgary, Alb. Vulcan-Cincinnati, Inc., will supply all engineering and equipment for the new unit. The plant will employ the Inventa-Vulcan urea process, and Vulcan-Cincinnati will supply facilities for total recycle of ammonia off-gas. The firm also will provide a hot-carbonate system for the purification of ammonia synthesis gas by removal of carbon dioxide.

To be completed in 10 months, the plant will be designed to operate in outside temperatures as low as —50° F, and will be integrated with other nitrogen products operations at the Calgary site.

U. S. Industrial Chemicals Co. is planning a new increase in production capacity of polyethylene resins—this time 50 million pounds. This will bring total company capacity to 300 million pounds per year. U.S.I.'s Houston plant, opened in March, is already being upped from 75 to 150 million pounds, and with this new expansion it will reach a capacity of 200 million pounds annually. At its other plant in Tuscola, Ill., U.S.I. is producing 100 million pounds of polyethylene per year.

Expansions are expected to be complete by mid 1960.

Ashland Oil & Refining Co. has placed on stream a new multi-purpose super fractionation unit consisting of three 50-tray towers and one 60-tray tower at its refinery near Catlettsburg, Ky.

Designed to provide a wide range of products split from special feed stocks, the plant is highly adaptable to specialty product demands. Current production is primarily in commercial and specialty solvents. The unit, which can supply a substantial portion of the national demand, also is designed to produce special fuels for missile and jet engine development, and offers a number of residual benefits for development fuels for the

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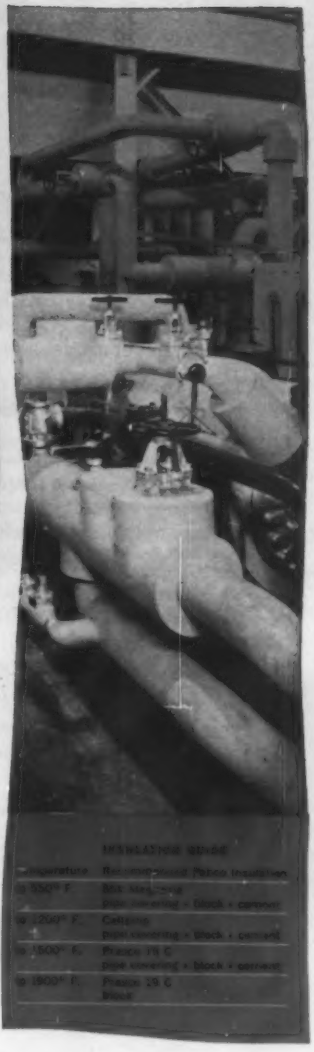

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easy way to keep tubular equipment good as new

Airetool tubular maintenance tools give work crews everything they need to clean boiler condenser and heat exchanger tubes faster, more efficiently. These tools are designed with plenty of power to get the job done right — in a hurry.

The lightweight Model CC-475 Airetool condenser and heat exchanger tube cleaner drives cleaning heads through hardest deposits without stalling . . . at the same time, a built-in flushing system washes out debris. Yet this hard-working tool weighs only 10 pounds — one man handles it easily without a supporting rig. And, when it comes to retubing bundles, Airetrol, automatic tube expansion control can't be beat. It easily rolls up to twelve ¼" to 1½" tubes per minute.

For cleaning large diameter curved tubes Airetool air-driven cleaner head motors produce high speeds and extra power for heavy duty performance. Motors maintain speed and power even when the most severe deposits are encountered.

For complete information about these time and money-saving Airetool tube maintenance tools that keep condenser and heat exchanger tubes operating at like-new efficiency, write for Bulletin No. 66.

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Building . . .

automobile engine industry.

Four fractionating towers in series are in the unit—the first, nine feet in diameter and 122 feet tall, containing 50 trays; the second, ten feet in diameter and 122 feet tall containing 50 trays; the third, six feet in diameter and 117 feet tall, containing 50 trays; and the fourth, six feet in diameter and 140 feet tall, containing 60 trays. The unit has an integral circulating hot-oil heating system with an output of 70 million Btu's per hour. Overhead condensers are air-cooled. Four motor-driven, variable-pitch fans circulate air from beneath the condensers and change condensate temperature automatically.

The unit is capable of making extremely narrow cuts in feet stock with a 20°F boiling range.

Feed stock for basic solvent production is a virgin naphtha from the refinery reforming unit prefractionator bottom or side streams, treated and desulfurized, or prefractionator overhead. The plant was designed to receive a feed stock input of 8,400 bpd, with average production of 4,000 bpd. No maximum production figures have been planned, although initial production indicates that as much as 10,000 bpd could be processed into finished products. Construction of the new unit was by Procon, Inc.

Imperial Oil, Ltd., has placed on stream its new 14,700-bpd refinery at Calgary, Alb. The $14-million project, begun 18 months ago, was the "largest single refinery building program ever undertaken on the Canadian prairies."

Facilities include new distillation towers, a new catalytic cracker and a Powerformer for manufacturing high octane gasolines. The plant, located on 340 acres bordering on the Bow River, has storage facilities for 1½ million barrels of crude oil and refined products. Construction work was begun in Spring, 1958.

The plant's capacity is almost double that of the old refinery and four times the capacity of the original refinery built on adjacent ground in 1923.

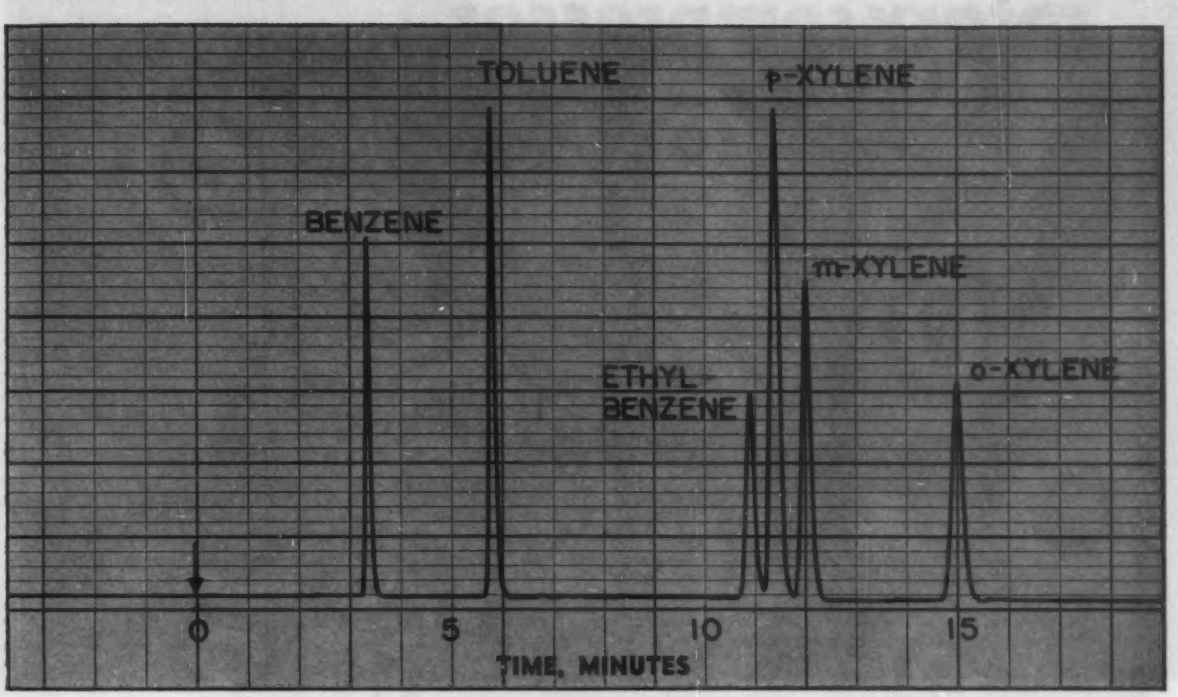
Tidewater Oil Co. is constructing a gasoline plant in the Hollywood-Houma Fields area, Terrebonne Parish, La., on a 9.2 acre tract four miles west of Houma.

The plant will process 75 MMcf per day of separator residue gas. It will be the low-temperature absorption type designed to operate at 0° F and at a pressure of 1,030 psi. It is designed to recover 85 percent of the propanes and virtually 100 percent of the butanes and heavier gas liquids contained in the lease separator residue gas.

Liquid recovery is calculated to be 1,030 bpd of propane, butanes and natural gasoline. Facilities will be provided for moving the products either by tank truck or by rail in tank cars. United Gas Pipe Line Co. will continue to purchase a volume of plant residue gas

Another Wheelco *first*—

New tritium detector means less base line noise, greater sensitivity



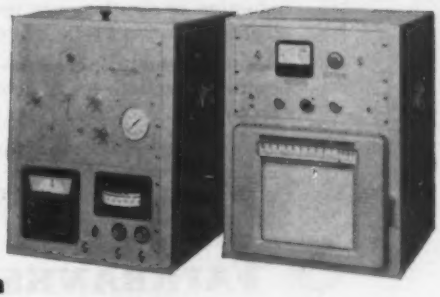
Chromatogram showing complete separation of xylenes using tritium detector and 60-ft stainless steel capillary column. Temperature, 67°C; flow rate, 0.7 ml/min Argon.

Now Wheelco offers a new tritium detector — to 225°C — in addition to the time-proved ionization detectors using strontium 90 and radium. Sensitivity is greater because tritium detectors have less base line noise than any other radioactive source: 1/3 as noisy as strontium and 1/30 as noisy as radium.

With a tritium source the detector offers the ultimate in simplicity and can be cleaned regularly. Long life with practically no maintenance or replacement is assured.

Outstanding operating flexibility is provided because the same detector can be used for capillary or packed columns.

See Wheelco first before selecting any chromatography equipment. New developments based on extensive field experience keep Wheelco ahead of the rest.



Model 20 is a compact, portable unit designed to use both capillary and packed columns. Wheelco also builds the Model 10, a laboratory unit for single or dual operation.

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Wheelco Instruments Division

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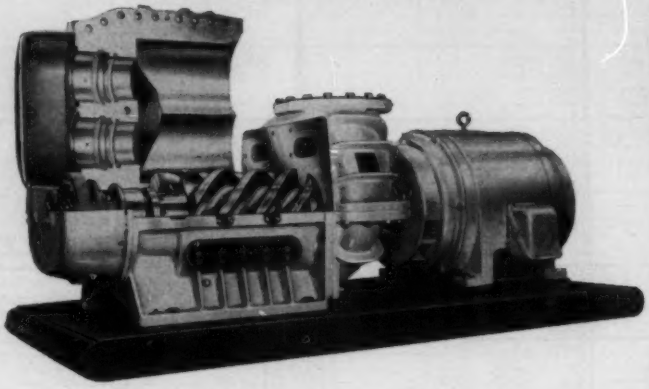
You'll find this is

the only rotary compressor

with all these features!



Fairbanks-Morse Positive Displacement Axial-Flow Rotary Compressors are available in standard models in single-stage units, with capacities from 800 to 12,500 cfm. at compression ratios from 1.6:1 to 5.0:1—or in two-stage units with capacities from 2,000 to 12,500 cfm. at compression ratios above 5.0:1—and for booster service at maximum working pressures up to 250 psig.

- **High efficiency and stability** that rivals reciprocating machines.
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- **Adaptability to any power source** permits choice of induction or synchronous motor, diesel engine, gas or steam turbine as prime mover.
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Building . . .

comparable to the volume currently being purchased from the lease separators.

The new plant will lend itself favorably to the installation of additional facilities to obtain up to approximately 50 percent of ethane recovery.

O. L. Olsen Co., Inc., Houston, is the contractor and anticipates that the plant and related facilities will be completed by the third quarter of 1960. Cost will be in the range of $1.5 million.

Pan American Petroleum Corp. and Hondo Oil and Gas Co. plan to construct a gasoline plant in the Empire Abo Field, Eddy County, N.M. It will be operated by Pan American for itself and Hondo, each of which will own a 50 percent interest. Construction of the plant, to be located about 13 miles Southeast of Artesia, N.M., will begin before January 1, and is slated to begin operations during the first half of 1960.

The new plant will be designed with compressor capacity of 10 Mmcf of casinghead gas per day and processing capacity of 15 Mmcf. Operating at design rates, it will recover about 42,000 gallons per day of liquid product from a refrigeration type plant. The product will be fractionated into propane, butane and gasoline.

An amine unit for gas sweetening and a sulfur recovery unit will also be installed as part of the plant facilities. Some 12½ long tons of elemental sulfur will be recovered daily from the hydrogen sulfide content of the casinghead gas.

Initially, the plant will have a compressor installation totaling about 2,700 hp, with provision for possible expansion later if continuing development of the field warrants. Residue or dry gas will be compressed to a pressure of 1,000 psi.

With the exception of the sulfur unit, engineering of the new plant will be done by O. L. Olsen Co., Inc., Houston. Pan American designed the gas coltion system.

The plant will be largely automatic, being designed for unattended operation 16 hours a day.

Australian Synthetic Rubber Co. Ltd. has named Fluor International, S.A., prime contractor to engineer and construct Australia's first synthetic rubber plant. The $10-million facility will be located at Altona near Melbourne, and it will commence production in 1961.

A joint venturer with Fluor International in construction of the project is Utah Australia, Ltd., a subsidiary of Utah Construction Co., San Francisco.

The contract is another major step in developing a $50-million, four-plant complex planned to begin large-scale petrochemical production in Australia.

Vacuum Oil Co., Pty., Ltd., Australian Synthetic Rubber's parent company, awarded a contract to Fluor-Utah last June to engineer and construct the basic plant of the complex. This $28-million installation will process selected hydrocarbons from Stan-Vac's Altona refinery to supply butadiene to the synthetic rub-

The X-ray fluorescence analyzer, one of the many modern instruments in the chemical laboratory, helps Jessop make certain you get the specified per cent of each alloy in your specialty steel.

"How X-rays help Jessop give you exactly what you want in alloy steels . . ."

—C. M. Carlisle, Director of Analytical Chemistry

"What's happening here? As the stylus in the X-ray fluorescence analyzer draws red lines on the graph, the Jessop chemist determines the exact per cent of each alloy in a sample of specialty steel.

"Based on this analysis, the melter may ask for the addition of, say, molybdenum to the molten steel now in electric arc furnace No. 3.

"How's it done? Bombarded by X-rays, the alloys in the sample of steel are radiating secondary rays. Converted into electrical energy, the rays are causing the stylus to move and draw red lines on the graph . . . indicating the types and per cent of alloys in the steel sample."

In the Jessop chemical laboratory, the X-ray fluorescence analyzer and many other modern instruments help us make certain you get the exact chemical composition specified in your order. This chemical laboratory is one more reason for your confidence in ordering specialty steels from Jessop. *Specify Jessop . . . and then relax!*

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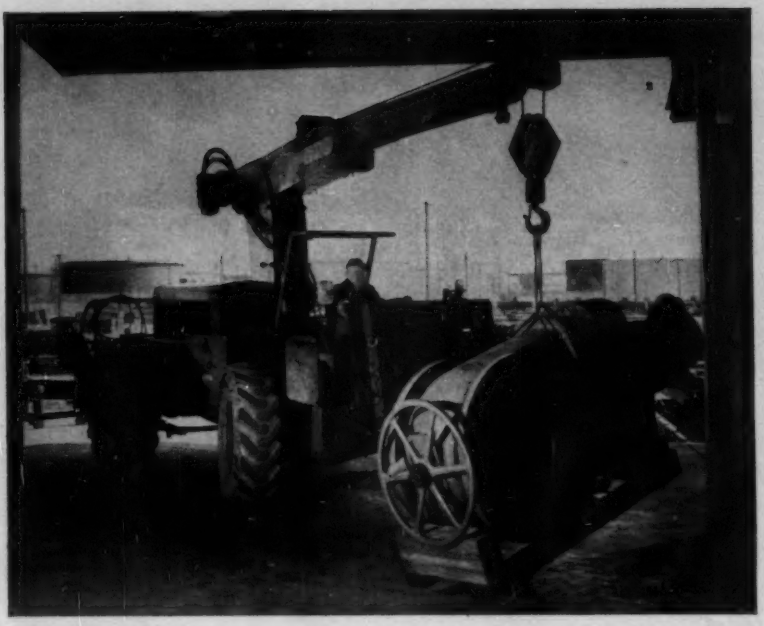


A-W crane carries 5000-lb. gate valve through low warehouse doorway. Crane requires minimum 10½-ft. overhead clearance.

Seven A-W cranes help Atlantic Refining reduce maintenance costs

"Since 1956, we have reduced the cost of crane maintenance by about 30% through the use of A-W equipment," says Walter O. Hoffman, general superintendent of Atlantic Refining Company's service division, Philadelphia, Pa.

Fast, highly maneuverable

As a result of a careful evaluation of crane performance in every maintenance operation, Atlantic Refining now has a fleet of six self-propelled, rubber-tired cranes and one truck-mounted unit.

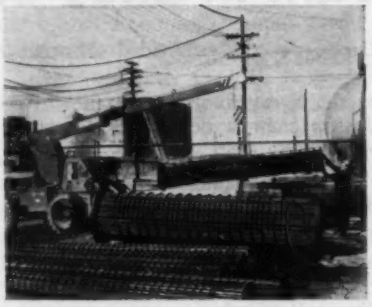
These highly maneuverable cranes, with all-wheel steering, work close to equipment, travel at traffic speeds, and pass under overhead obstructions as low as 10½ ft.

The A-W's handle 75% of all lifting jobs in the refinery. For instance, an A-W can lift out an exchanger bundle, carry it to the repair shop, position it for mechanics, and later reverse the process to speed installation of the repaired unit.

Mr. Hoffman adds, "The efficiency of our maintenance force depends greatly on the efficiency of the equipment it has to work with. The adoption and use of the Austin-Western hydraulic cranes is an example of our continuing effort to provide the most efficient equipment available!"

Reduce your costs

Learn how all-wheel drive and all-wheel steer A-W cranes can reduce maintenance and handling costs in your operation. Complete crane line now available—varying capacity ranges and boom lengths. Get all the facts today from your nearby Austin-Western distributor or write us direct.



Precision hydraulic control simplifies removal, handling, repair and maintenance of delicate heat exchanger bundles.

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Building . . .

ber plant and ethylene to a styrene plant and to a polyethylene plant.

The rubber plant will co-polymerize butadiene and styrene to produce 30,000 long tons of GRC synthetic rubber a year.

The Fluor Corp.'s Los Angeles staff will engineer the plant, which will use a Goodyear Tire & Rubber Co. process. Construction of the installation is scheduled to begin early next year.

Husky Oil Co. has started work on a major modernization and expansion of its Cody, Wyo., refinery. The program will add new catalytic cracking and alkylation units and increase the refinery's throughput capacity from 7,000 to 9,000 bpd. The expansion also includes construction of a 100-mile finished products pipeline to Billings, Mont., to be completed late in 1960 at a cost of $8 million.

Bureau of Mines has completed a $10-million helium recovery plant. The installation, constructed by The Fluor Corp., is located on a 188-acre site in the Keyes natural gas field—15 miles from Boise City, Okla. It was designed to extract helium from more than 50 MMcf of natural gas a day. Keyes field natural gas contains about two percent helium.

Fluor, in engineering the plant, used as its guide a basic process design developed by the Bureau of Mines. The installation is made up of low-temperature helium separation units, carbon dioxide removal and dehydration equipment and compressors.

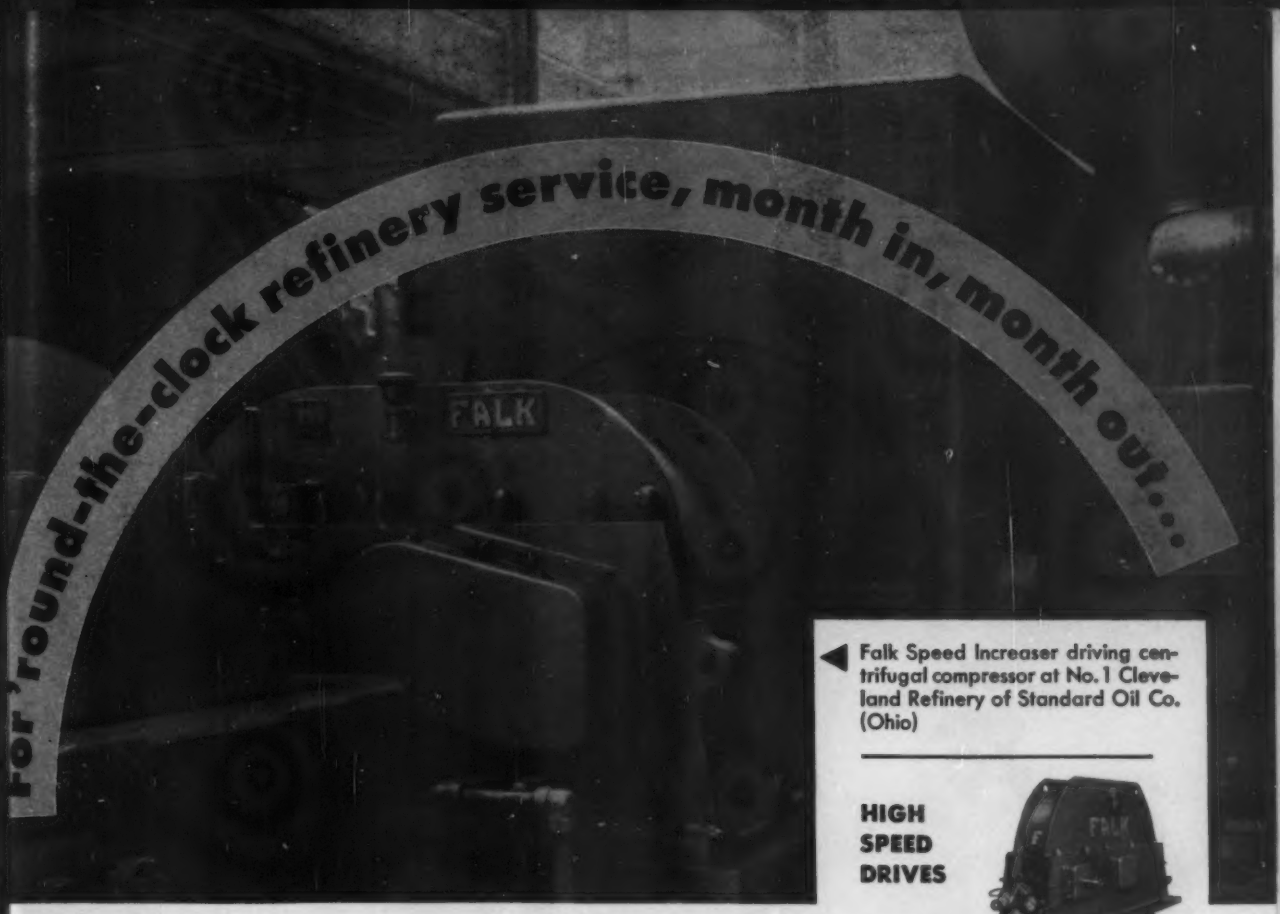
By this time next year, it is expected to produce approximately 300 MMcf of crude helium for further refinement in Bureau-installed equipment. Completion of the new unit raises the current U.S. production rate of helium by 65 percent. Even so, government officials have expressed the view that it may be difficult to meet mounting demands for the rare gas after next year.

Helium has been in short supply for several years as there has developed a newly-vital need for it in national defense and in industry. Today's consumption of helium, consequently, is 70 times greater than it was 20 years ago.

Union Carbide Corp. will, in April 1960, begin conversion of the recently purchased facilities at Brownsville, Texas, into a chemical plant to produce a "wide variety" of chemical solvents and intermediates.

Carbide announced last December that it had exercised its option to buy from Amoco the usable facilities remaining on the 309-acre tract near Brownsville. The option also included the 42-mile Weslaco-Brownsville natural gas pipeline. Carbide is leasing the property on a long-term basis from the Brownsville Navigation District.

Operations at Brownsville will be carried on by Union Carbide Chemicals Co. and Union Carbide Olefins Co., both



◀ Falk Speed Increaser driving centrifugal compressor at No. 1 Cleveland Refinery of Standard Oil Co. (Ohio)

FALK offers a complete line of standard high speed and semi-high speed drives

type P Ratios—from 2.5:1 to 12.0:1.
Horsepower—up to 2000 hp per 1000 rpm of high speed shaft.
Maximum speed of high speed shaft: 10,000 rpm.

type Q Ratios—from 1.15:1 to 9.5:1.
Horsepower—up to 1800 hp per 1000 rpm of high speed shaft.
Maximum speed of high speed shaft: 10,000 rpm.

type H Ratios—from 2.22:1 to 9.89:1.
Horsepower: up to 1100 hp.
Maximum speed of high speed shaft: up to 3600 rpm.

type S Ratios—from 1.49:1 to 25.4:1.
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SPECIAL DRIVES...to any required speed and horsepower.

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Designed and produced by the Falk engineers who pioneered the ultra-high speed gear units for aviation turbo engine test facilities, Falk standard high speed drives are widely used in refineries throughout the country. Our technicians will be glad to work with your engineers or with your equipment suppliers to select and produce drives precisely suited to your operation.

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Building . . .

divisions of Union Carbide Corp.

It is expected that about 500 construction people will be employed, and that the plant, when in operation, will employ about 200 people. Completion is scheduled for March 1961. A construction contractor has not yet been selected.

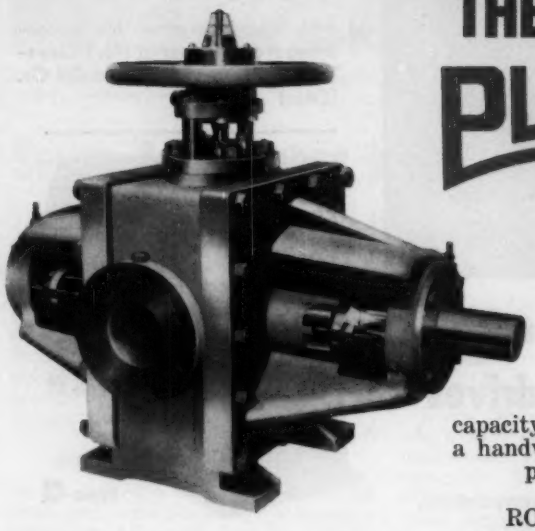
Mobil Oil Co. has completed a new gas and distillate separation and recovery facility in Cameron Parish, La., near the Gulf Coast. The $2.5-million unit is designed to process 150 MMcf of gas per day. Construction of the plant was begun by Magnolia Petroleum Co., which recently became Mobil Oil.

Humble Oil & Refining Co. is planning construction of a new lube oil processing plant and a major expansion of two existing lube plants at its Baytown Refinery. The new plant will be a 9,500-bpd lube hydrofiner. It will use a catalytic hydrogen treating process to remove sulfur compounds and other impurities from the lube oil feed stocks.

The plants to be expanded are a lube dewaxing plant and a lube extraction plant. Engineering work for these projects is in progress, and construction is scheduled to be completed during the latter part of 1960.

INTRODUCING FROM KEARNEY INDUSTRIES

THE RO-VAR PLENTY PUMP



The unique maintenance free RO-VAR PLENTY positive displacement pump is now being manufactured and sold in the U. S. Variable capacity can be obtained with a handwheel, or with remote pushbutton panel board control for blending. RO-VAR PLENTY is the answer for pumping viscous liquids (up to 500,000 cps.), and accurate inline blending without complicated controls. Discharge pressures to 450 psig. 17 sizes with capacities from 0-1, to 0-3000 gpm.

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Full reverse flow
Constant Pressure Control

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KEARNEY INDUSTRIES FLUID EQUIPMENT DIV.

P. O. BOX 501 **SO. PLAINFIELD, N. J.**

Florida Oil & Refining Co. has purchased a deep water refinery site at Jacksonville, Fla., for construction of a 10,000-bpd plant. The Frontier Refining Co. subsidiary will produce regular and premium gasoline, butane, propane, kerosine, jet and diesel fuel, gas oil, heating oils, bunker "C" fuel oil and possibly asphalt.

Texas Eastman Co. has begun commercial production of polypropylene plastic on a limited basis. The company has been making pilot plant quantities of the material for more than a year, during which time it has been undergoing extensive testing and evaluation at Eastman laboratories. The process being used was invented in Eastman's research laboratories. Texas Eastman is already a producer of high purity propylene, the raw material for the new plastic.

Bay Petroleum Co. has completed a new natural gas processing plant on Copano Bay near Rockport, Texas. It will process 50 MMcf of natural gas per day, from which liquefiable petroleum gases are extracted. Daily output of these products—propane, normal butane, isobutane and natural gasoline—will be about 45,000 gallons.

Situated on a 30-acre tract, the plant is about eight miles northeast of Rockport, just off Texas Highway 35.

E. I. duPont de Nemours & Co. is constructing an acrylonitrile plant at Memphis, Tenn., to be operated by the Electrochemicals Department. The process for the plant uses hydrogen cyanide and acetylene.

Petrofina, S.A., Brussels, Belgium, and Amoco Chemicals Corp. have formed a new company, Amoco Fina, S.A. The firm will manufacture and market additives for petroleum products in the European common market. A plant at Antwerp, to go on stream in 1961, is to undergo construction soon.

Antar-Petroles de l'Atlantique plans to build a new topping unit at its Donges refinery near Paris. According to the company, the move was made because of increased consumption and the need to process, under the best conditions, Saharan crude oil—to be the company's main supply for the future. The plant will have a capacity of 62,000 bpd.

British Petroleum Co. has completed a 6,500-bpd hydrofiner at Porto Marghera refinery, near Venice, Italy. Jointly owned by BP and AGIP, it is the sixth such unit for the BP Group. The new plant is associated with a sulfuric acid manufacturing plant.

Arabian American Oil Co. is installing high-capacity centrifugal pumps and making piping changes at its Ras Tanura, Saudi Arabia, refinery, providing for production of two grades of asphalt simultaneously. A base-stock asphalt suitable for cutback grades will be produced directly by vacuum distillation. A second grade of asphalt for modern pipe coat-

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You can make major economies in the refining of corrosive crudes, or in any refining that involves very high temperatures, by replacing still convection banks with a Ljungstrom Air Preheater. This is how.

The radiant section of your still, operating with an Air Preheater, can deliver as much throughput (and possibly more) as was formerly possible using convection banks. And with an Air Preheater the oil tubes get the maximum amount of heat without the expensive heat- and corrosion-resistant alloys sometimes required for convection banks.

In addition, an Air Preheater provides other economies that you just don't get with convection banks. For example, an Air Preheater can cut fuel costs by 20%. It will promote high equipment availability by drastically cutting formation of slag and deposits. And an Air Preheater can take full advantage of the most modern fuel-burning equipment to give you much closer control of temperature—close enough to boost average product ratings as much as two octane numbers.

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Building . . .

ing will be produced at the same time by directing a slip stream of the base stock to a converter where it is air blown to meet the very low penetration specification required.

Phillips Chemical Co. plans to further expand ethylene capacity at its Sweeny, Texas, plant by 35 million pounds per year. The increase is in addition to one of 75 million pounds per year which went on stream early in October. Upon completion of the new expansion in the second quarter of 1960, the plant's annual capacity will be 290 million pounds.

South Louisiana Production Co. has begun construction of a $250,000 natural gas processing plant near Jeanerette, La. The new plant will have facilities to extract butane, propane, and other LPG from natural gas.

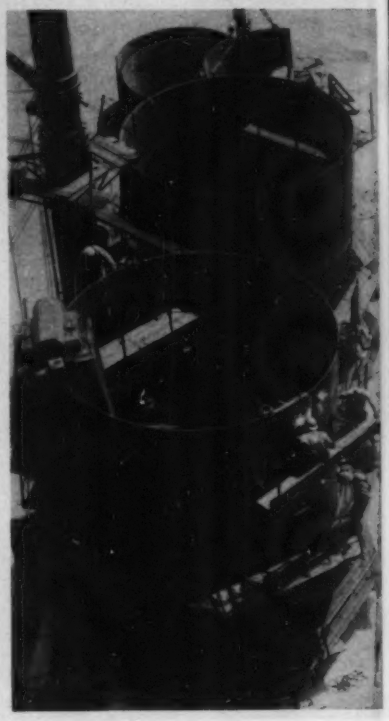
Bay Petroleum Corp. has begun construction of a $10.5-million addition to its refinery at Chalmette, La. The expansion is slated for completion by May 1960.

Shell Chemical Co. will produce its new polystyrene thermoplastics in American Cyanamid Co.'s Wallingford, Conn., plant. Production is to start on a small scale this year to confirm pilot plant studies by Shell.

Union Carbide Corp. plans to build a 25-million-pound-per-year plant at Marietta, Ohio, for production of bisphenol-A. The plant is slated to have the product available commercially early in 1961. The company, which is also an epichlorohydrin producer, emphasizes that the new venture is linked with the epoxy resin plant brought on stream earlier this year at Marietta by Union Carbide Plastics Co.

Construction Progresses On GP's Torrance Plant

General Petroleum Corp. is well underway with construction of its new Mobil refinery at Torrance, Calif. When completed, the new unit will have a planned throughput of 9,300 bpd, increasing the refinery's coking capacity to 35,000 bpd. Pictured are giant drums which will be a major part of the refinery's new coking unit, scheduled for completion in the first quarter of 1960. The drums are 17 feet in diameter.



Reichold Chemicals, Inc. has completed a $500,000 formaldehyde plant at Kansas City, Kansas. The 30-million-pound-per-year unit is the company's seventh domestic formaldehyde unit.

Pechiney S.A.A. plans to build a polystyrene and saran plant at Ribecourt, near Paris. The French chemical firm

For complete construction news read REFINER's "Construction Boxscore" (January, April, July and October).

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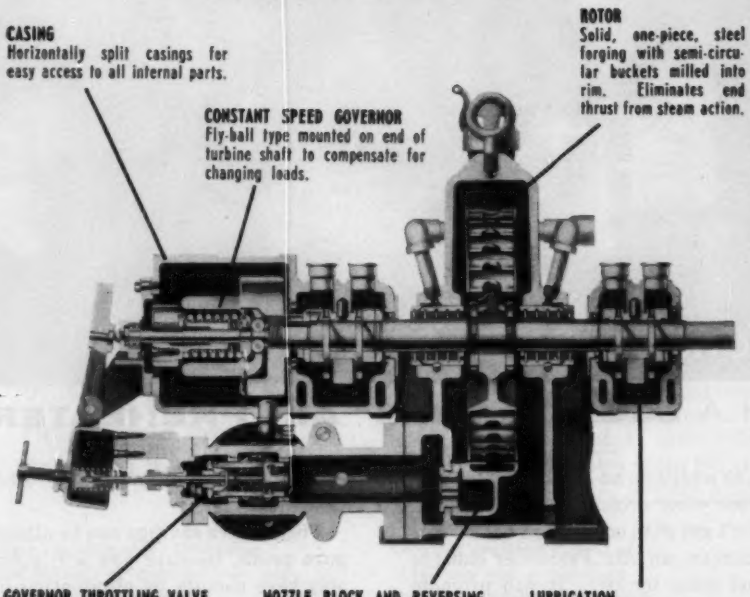
For almost 50 years, Whiton has combined experience, workmanship and **precision engineering** in building high quality, reliable steam turbines for all types of power and drive applications. Whiton horizontal, helical-flow, single stage turbines are available in 8 wheel sizes. Axial-flow, Curtis-blade turbines are also available. Write for complete data on Whiton's horizontal and vertical turbines.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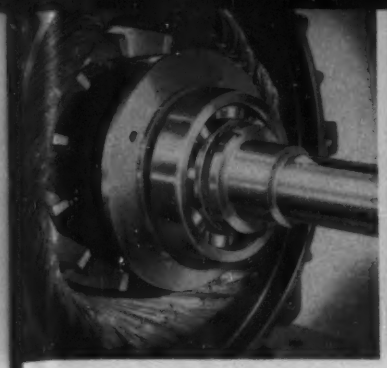

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BEARINGS CAN BE RELUBRICATED . . . Original factory lubrication will last for years in normal service—but convenient grease plugs are provided to permit relubrication that adds to motor life under severe conditions.

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Here are motors that will deliver full-rated horsepower under the toughest service conditions—that will help you keep your production rates up, and give you the kind of dependable, continuous operation that is so important to automation.

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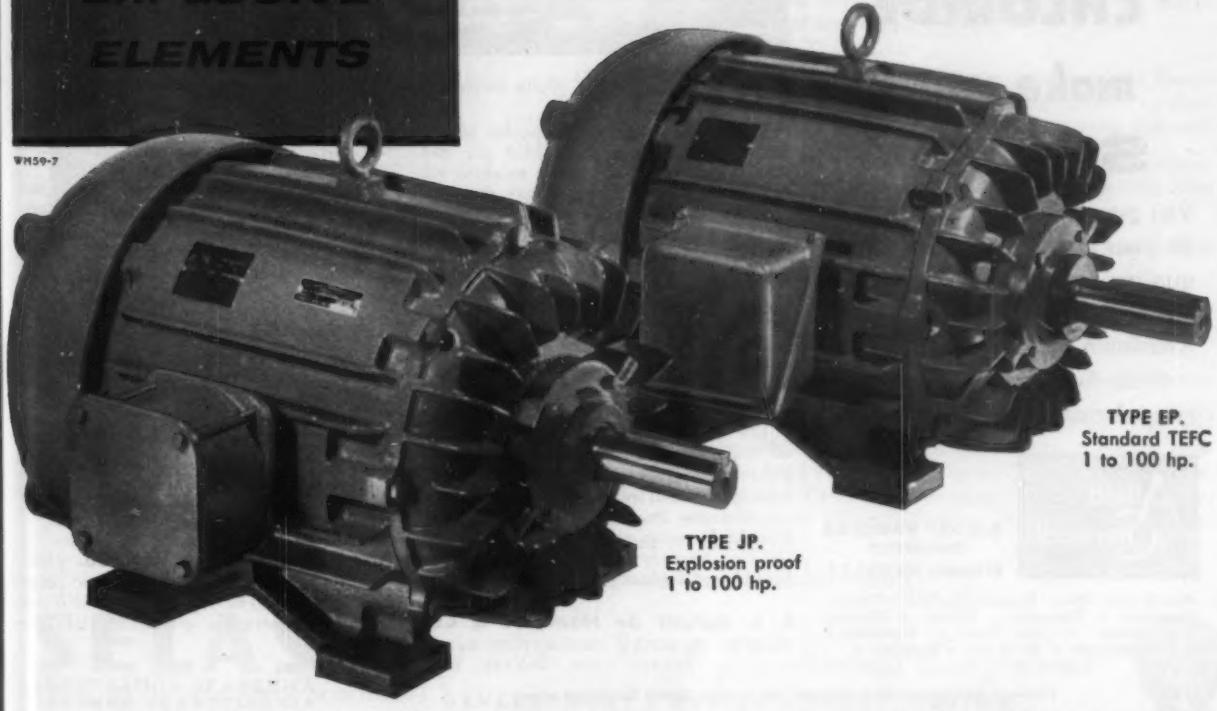

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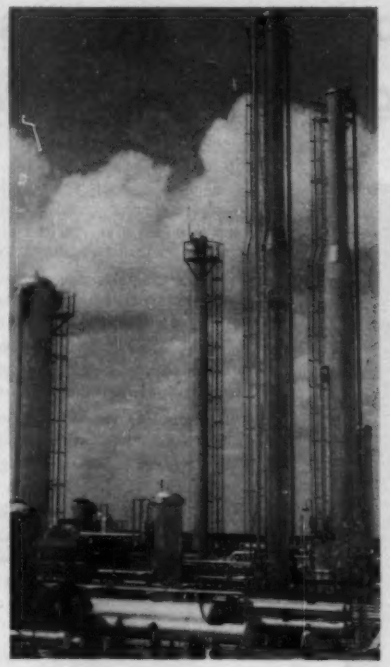
Building . . .

will join Dow Chemical International, Ltd., S.A., to form a new company, Plastichimie S.A., to operate the plant. The unit will undergo construction later this year and is slated for completion in 1961.

Arkansas Fuel Oil Up With Texas Gas Processing Plant

A new natural gas processing plant has been placed in operation by Arkansas Fuel Oil Corp. Construction on the new plant, located 15 miles south of Kingsville, Texas, began in April. The con-



struction contractor was Delta Engineering Corp., Houston.

Maximum design gas capacity of the May Field plant is 50 MMcf per day with design provisions made to allow for future expansion as other gas developments in the area take place. The plant is designed to operate partially unattended and will require minimum personnel.

At present, the plant is processing 34 MMcf of gas per day from the May and South May Fields, recovering 29,000 gallons of natural gas liquids daily. Products to be sold are propane, butanes and natural gasoline.

The new unit is owned by AFO and six other companies. AFO has an 80 percent interest in the plant and has been designated operator. Other owners are Herman F. Heep, Sun Oil Co., J. Ray McDermott and Co., Inc., Mokeen Oil Co., Renwar Oil Corp. and Champlin Oil and Refining Co.

E. I. duPont de Nemours & Co. plans to up methyl methacrylate monomer capacity at Belle, W. Va., by 40 percent.

Sun Oil Co. has a $2-million propylene unit under construction at its Marcus Hook, Pa., refinery. The 120-million-pound-per-year unit will produce propylene with 99 percent purity, made from simple fractionation of propane, ethane and butane from catalytic cracking units and gas stabilization plants. The plant is slated for completion by the end of the year.

American Cyanamid Co. is increasing maleic anhydride capacity of its Bridgeville, Pa., plant from 14 million to 20 million pounds annually. The facility is to be on stream by the end of this year, and the expansion is to take about seven months for completion.

Hercules Powder Co. plans to triple dimethyl terphthalate capacity at Burlington, N.J. The expansion, to be comepleted in October 1960, will up capacity from 12 million to more than 36 million pounds per year. The units will use an advanced version of air oxidation of p-xylene.

Firestone Tire & Rubber Co. plans to build a plant in France for the manufacture of special synthetic latices and copolymers of butadiene and styrene. Exact location of the facility, which will be erected in conjunction with a new tire plant, has not been chosen.

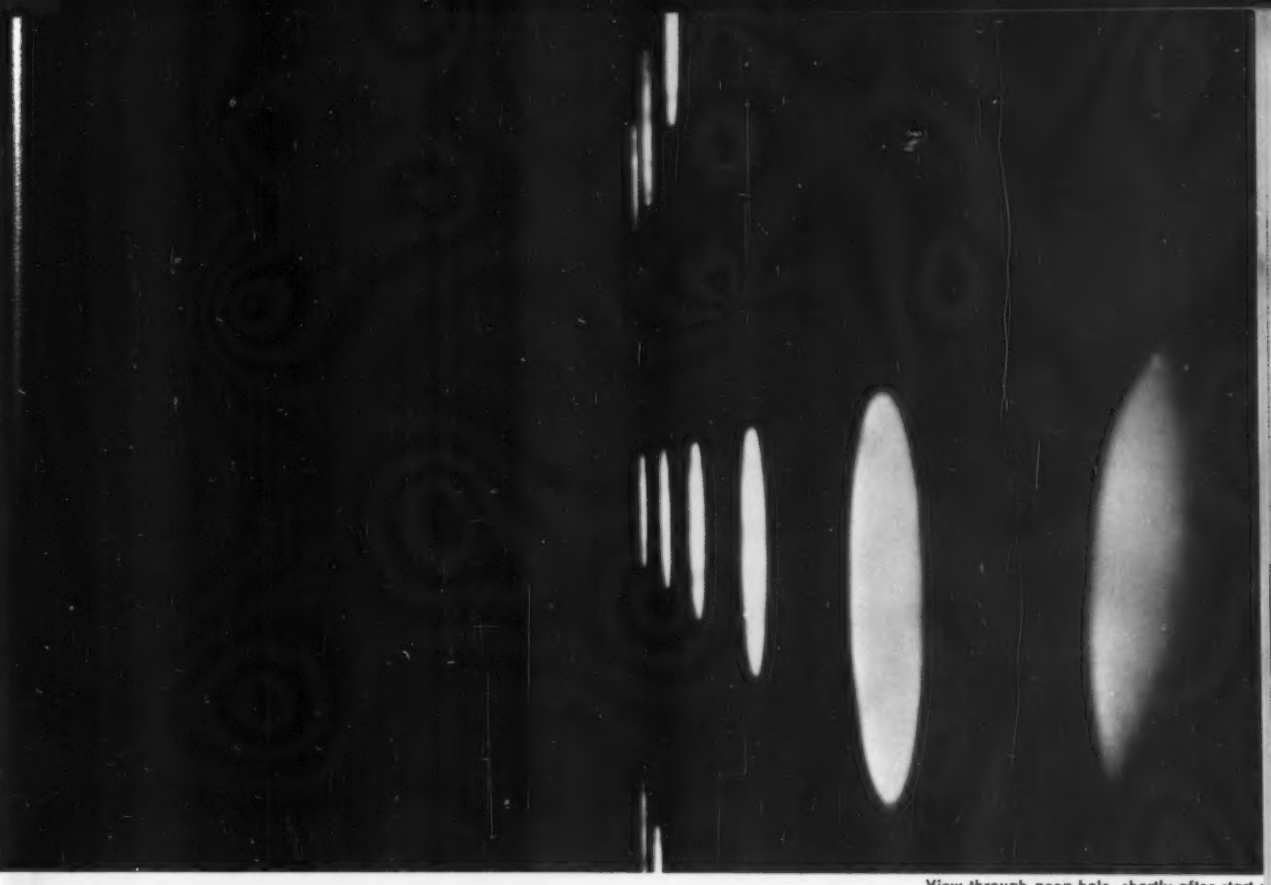
Wintershall, A. G. is expanding capacity of its refinery at Salzbergen, West Germany, from 2,300 bpd to 4,300 bpd. To be completed late in 1960, the plant will run naphthene-based crude oil from the Cabimas field in Venezuela. It currently handles paraffin-based crude oil.

Monsanto Chemical Co. has begun construction of a 50 percent expansion of its bisphenol-A capacity at the John F. Queeny plant, St. Louis, Mo. The company currently manufactures between 10 and 12 million pounds per year of the product.

Ethyl Corp. of Canada, Ltd., has awarded a contract for Phase 1 construction (foundation and underground work) of an Ethyl Chloride-Ethylene Dichloride unit to Canadian Badger Co., Ltd. Construction of the plant is underway at the Ethyl plant, Corunna, Ont.

AviSun Corp. has placed on stream a new 20-million-pound-per-year polypropylene plant at Koppers Co., Inc.'s plant, Port Reading, N. J. AviSun personnel are directing technical details, while Koppers employes are operating the plant. Facilities are being leased from Koppers.

B. F. Goodrich Chemical Co. plans to build a $4.5-million vinyl plastic plant in Australia. The new facility will be built in cooperation with Australian interests.



View through peep-hole, shortly after start-

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These benefits apply to *horizontal*, as well as *vertical*, Gradiation tubular furnaces.

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Man and Raw Materials

"Man and Raw Materials" discusses the major political, economic, and technological factors affecting raw material availability; the geopolitical implications of raw material resources and production; and the problems confronting industrial nations in their access to raw material resources in the backward areas of the world. The author covers national and international raw material policies and the industrial and military power inherent in the resources and potential raw-material strength of the Sino-Soviet block. He also goes into the contrast of resource limitations on industrial growth in the United States and U.S.S.R.

(Pehrson, Edward W., *Man and Raw Materials,* American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., $1.25.)

Vapor Lock Factors

"Correlation of the Factors Which Affect Vapor Lock" (PB151437) contains information gleaned from current publications and through interviews with authorities in the automotive and petroleum industries. The report discusses the chances of vapor lock and describes efforts to curb the engine-stopping phenomenon. Reduction of vapor lock incidence brought about by improved fuel systems are discussed. Conflicting views are revealed by the automotive and petroleum industries as to the magnitude of the vapor lock problem and on a suitable method of expressing fuel volatility as related to vapor-locking tendencies. Areas where possible improvements can be expected are set forth.

(Dial, B. C., *Correlation of the Factors Which Affect Vapor Lock (PB 151437),* Office of Technical Services, U.S. Department of Commerce, Washington 25, D. C., 63 pages, $1.75.)

Current ASA Projects

"Current Projects of the American Standards Association" answers the following questions:

- Who is sponsor of the American Standard Code for Pressure Piping?
- What is the scope of ASA projects on common names for pest control chemicals . . . centrifugal pumps . . . heat exchangers?
- How many projects have been established to draw up standards in the nuclear energy field?

A total of 425 ASA projects are described. In addition to listing projects under 19 standards categories, the booklet describes the scope of each project, provides an index and lists sponsors. Where the project is handled by a sectional committee operating under ASA auspices, officers are listed.

(ASA, *Current Projects of the American Standards Association,* American Standards Association, Dept., PR 94, 70 East 45th St., New York 17, N. Y., 75 cents for ASA members, $1.50 for others.)

Computer Application

"Application of Analog Computers to Various Combustion, Flame and Fluid Dynamics Problems" (PB 151775) shows that analog computers can (while not widely used for the purpose) unravel problems of combustion, flame, and fluid dynamics which can't be solved by other means, according to this report. To support his point, the author used analog computers on problems like the solution of the equations of the study state laminar flame; the unsteady state laminar flame; flame phenomena in turbulent flow; simulation of the steady state detonation wave; and investigation of oscillations in a rocket motor. Methods of attack are given along with the computer equipment required. Possible topics for investigation are proposed, and results possible with analog computers are compared with those obtainable by other means.

(Williams, T. J., *Application of Analog Computers to Various Combustion, Flame and Fluid Dynamics Problems, PB 151775,* Office of Technical Services, U.S. Department of Commerce, Washington 25, D. C., 64 pages, $1.75.)

Oil Burning Equipment

"Standard for the Installation of Oil Burning Equipment" (NFPA No. 31) gives the fire safety requirements in the installation of oil burning equipment. The standard, purely advisory as far as the NFPA is concerned, is widely used as a basis of law and regulation throughout the United States and Canada. It covers use and installation of everything from home portable oil heaters to commercial and industrial oil-burning equipment.

(NFPA, *Standard for the Installation of Oil Burning Equipment, NFPA No. 31,* National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 64 pages, 60 cents.)

Men and Maintenance

"Equipment Maintenance with Various Numbers of Service Men: A Simple Analysis" (PB 151683) provides management with guidance against the ever-present problem of equipment maintenance. It suggests how the plant, service, or office manager decide whether to leave the equipment alone, have one man service it, or have a series of men service it? The simplified analysis is based on studies

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Books . . .

of the consequences of ways of assigning maintenance men. Foundation of the analysis is the probability theory.

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(Wright, G. O., et al, *Equipment Maintenance with Various Numbers of Service Men: A Simple Analysis (PB 151683)*, Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., 41 pages, $1.25.)

Fuel Oil Stability

"Symposium on Stability of Distillate Fuel Oils" give broad coverage to this topic. Among the papers are:

- Trials and Tribulations of a Large-Development Oil Heating—N. M. Edmands, Manager, Burner Service Dept., Meenan Oil Co., Inc., Levittown, N. Y.
- Predictive Type Tests for Storage Stability and Compatibility of Diesel Fuels—J. W. MacDonald and Reginald T. Jones, Fuels and Lubricants Div., U.S. Naval Engineering Station, Annapolis, Md.
- Requirements for Dependable Performance of Domestic Oil Burner Nozzles—E. O. Olson, Chief Engineer, Delavan Mfg. Co., West Des Moines, Iowa.
- Do We Need a Stability Specification No. 2 Heating Oil?—R. Gray, Editor, Fuel Oil and Oil Heat, New York, N. Y.
- A Review of the Distillate Fuel Stability Problem—E. A. Elmquist, Fuel Oil Applications Engineer, Shell Oil Co., New York, N. Y.
- How Distillate Fuel Stability Is Measured and Controlled—W. L. Clinkenbeard, Process Research Division, Esso Research and Engineering Co., Linden, N. J.
- Incompatibility of Distillate Fuels—C. C. Ward and F. G. Schwartz, Chemical Engineer, Branch of Chemistry and Refining, Petroleum Experiment Station, Bureau of Mines, Bartlesville, Okla.
- Distillate Fuel Oil Gel—F. R. Dunn, Jr. and R. W. Sauer, Research and Development Dept., Atlantic Refining Co., Philadelphia, Pa.

(ASTM, *Symposium on Stability of Distillate Fuels*, American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 56 pages, $2.75.)

Fire Protection

"Fire Prevention and Fire Protection" (PB 151695) was prepared by the Navy's Bureau of Yards and Docks for use by personnel responsible for construction and maintenance of Naval shore installations. It covers basic fire prevention measures, and includes requirements for construction, emergency and protective features, and safeguards against common hazards. In addition to the more common fire hazards discussed are special

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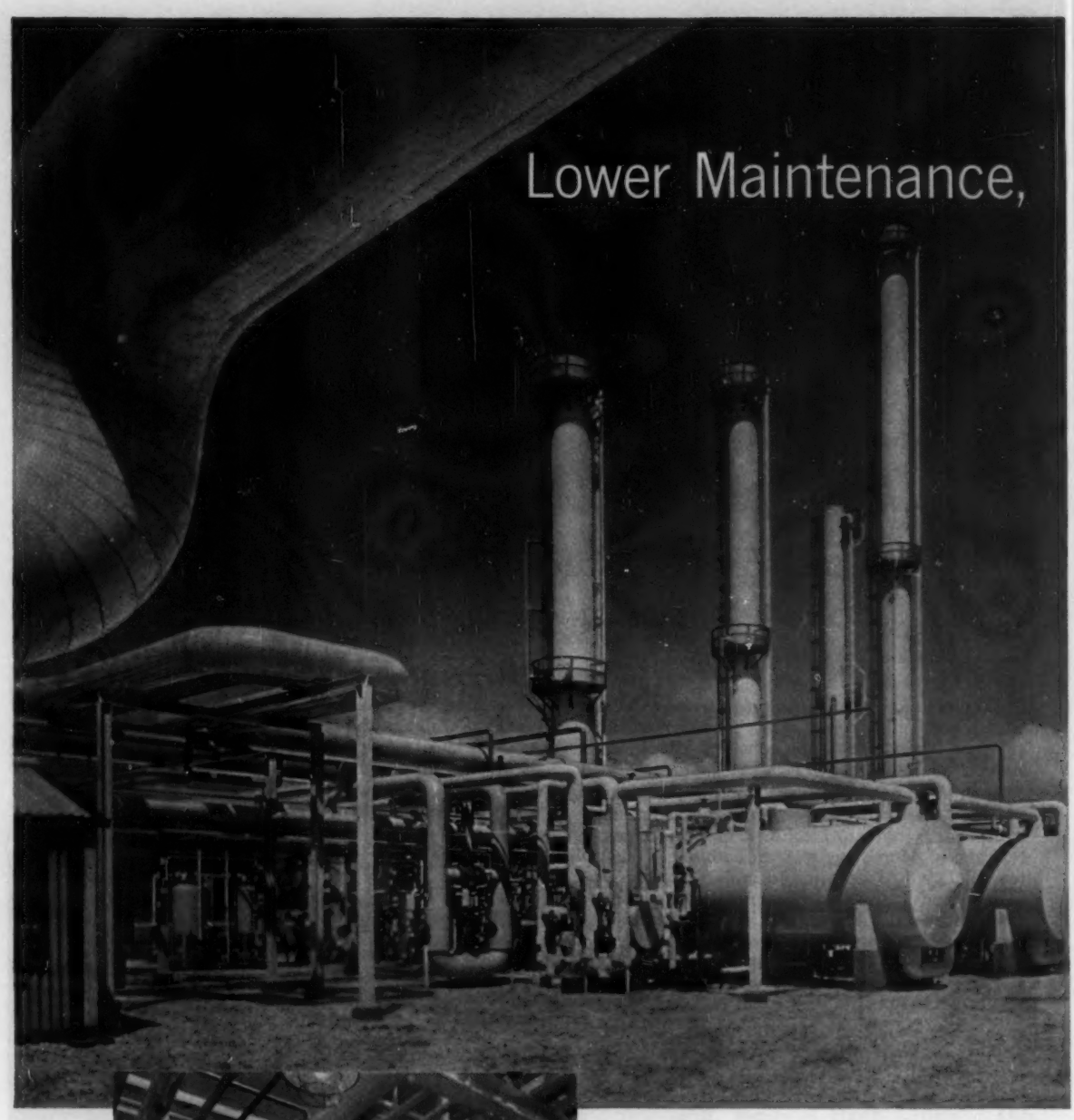

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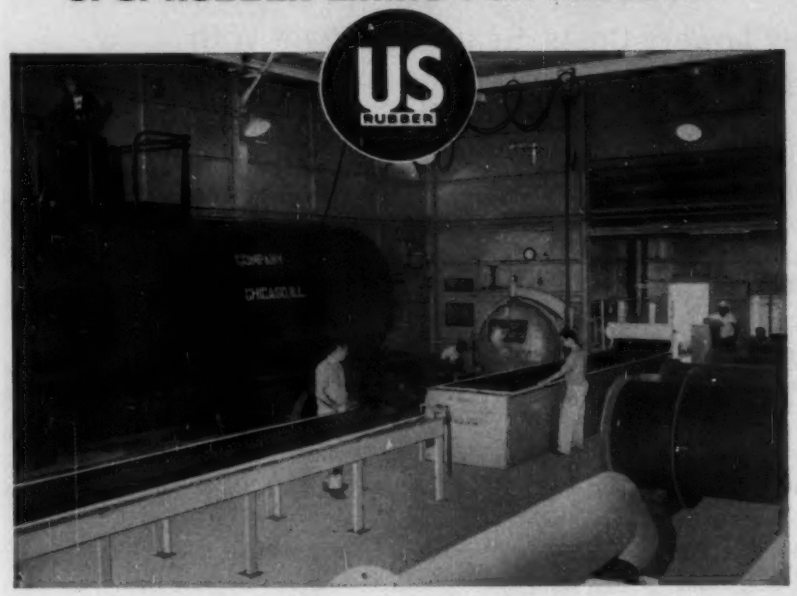

(Left) Muriatic acid tank car being prepared for patch job of rubber lining. (Center foreground) Flanged 16" pipe being lined inside with ¼" natural hard rubber with chlorine resistance properties. (Right) Dredge pipes, 40" in diameter, to be lined inside with abrasive resistant and oil resistant neoprene.

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hazards such as chemicals and metals, welding and cutting, operations, surface finishes, plastics, electricity, flammable liquids and gases, oil burners, rocket fuel, dust explosion, and woodworking.

(OTS, *Fire Prevention and Fire Protection, PB 151695,* office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., 190 pages, $3.)

Lightning Protection Code

"Code for Protection Against Lightning" (NFPA No. 78) is a guide to proper installation of lightning rods and other lighting protection. This year's revisions deal principally with concealed installations, floating roof tanks, grounding or tanks and pressure storage of flammable liquids and gases.

(NFPA, *Code for Protection Against Lightning, NFPA No. 78,* National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 48 pages, 50 cents.)

Lube Oil Performance

"Performance of Lubricating Oils" (second edition), summarizes and evaluates the wealth of data on performance characteristics of lubricating oils under various conditions. New subjects in this edition include multi-grade motor oils, fretting wear and paper chromatography. Entire chapters are included on lubrication processes, rheology, oxidation, bearing corrosion, sludge and lacquer deposition, emulsification and foaming, and manufacturing methods.

(Zuidema, H. H., *Performance of Lubricating Oils,* Reinhold Publishing Corp., 205 pages, $7. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Gas Chromatography

"Gas Chromatography" (second edition) adds the striking advances in practical details that have taken place since the original appeared in 1957. The most important of these are:

- The development, for highly critical separations, of columns having an extremely large number of theoretical plates.
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- The use of gas-solid chromatography for special purposes, such as the characterization of catalyst surfaces and the separation of isotopes.

A subject index is added, along with many other additions and revisions.

(Keulemans, A.I.M., *Gas Chromatography,* Reinhold Publishing Corp., 234 pages, $7.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

New-Plastic Source Book

"Source Book of the New Plastics" discusses the properties, production, price, applications and selection of the seven new primary plastics of 1958. It describes the significant recent improvements in established plastics, and the 100 most important patents issued in the plastics field for 1958. A section on graft copolymers

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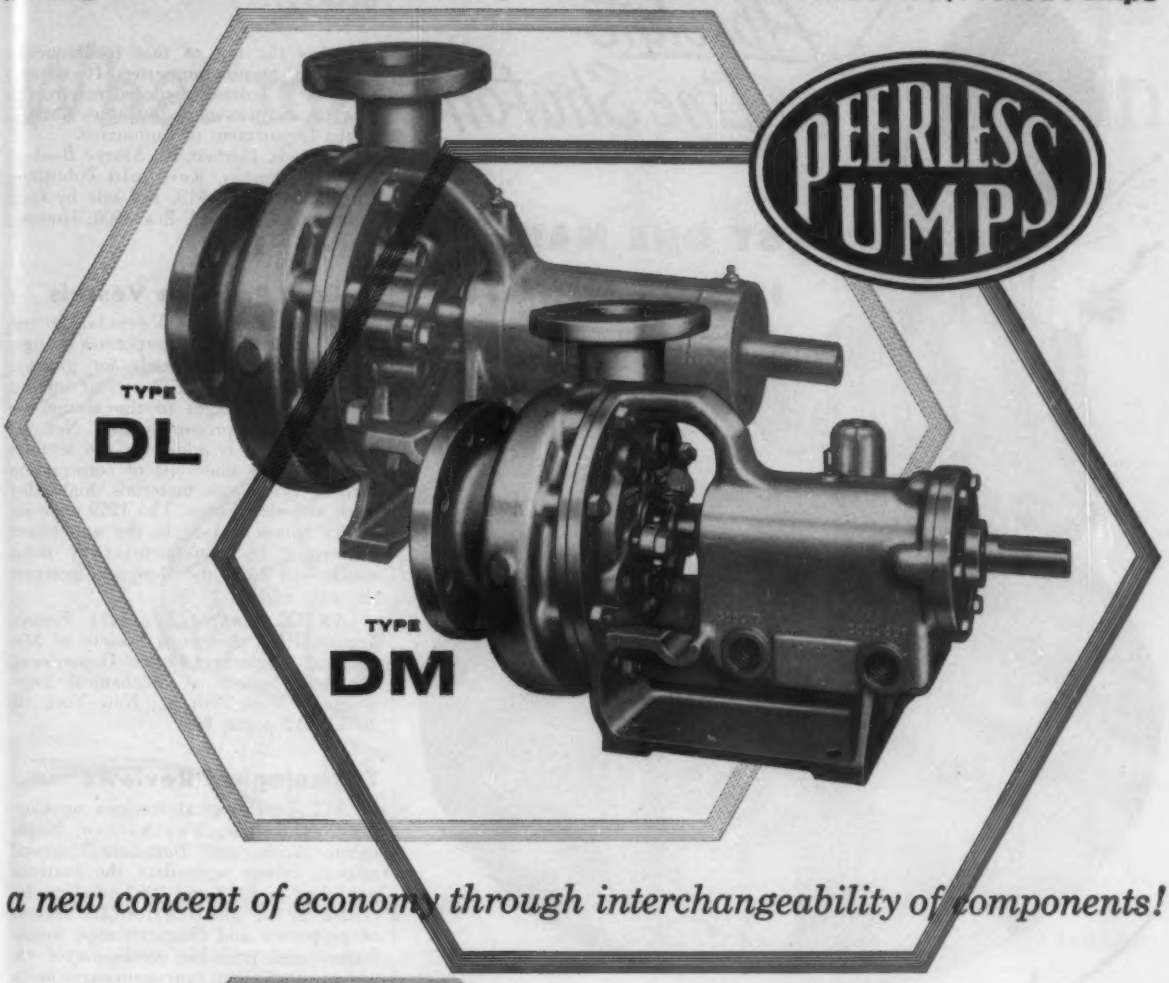

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Books . . .

describes the use of that technique in modifying plastics properties. It contains a survey of federal-sponsored research in plastics, and was made by James Kanegis of the Department of Commerce.

(Simonds, Herbert R., *Source Book of the New Plastics*, Reinhold Publishing Corp., 354 pages, $10. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Unfired Pressure Vessels

"Unfired Pressure Vessels, Section VIII," 1959 edition, incorporates changes made to the ASME code for pressure vessels since 1956. Of particular interest will be the changes to the section on welded unfired pressure vessels. New information also is added to the sections dealing with materials of construction such as nonferrous materials, high-alloy steel, and clad plates. The 1959 code includes a new section to the appendices concerning 16 non-mandatory items which will help the designer interpret the new code.

(ASME, *Unfired Pressure Vessels, Section VIII*. American Society of Mechanical Engineers, Order Department, American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., 212 pages, $6.)

Toxicological Reviews

"API Toxicological Reviews on Copper Naphthenate, Napthalene, Naphthenic Acids, and Butadiene," second edition, brings up-to-date the material published in 1948 and 1953 editions. Included in the publication are reviews of properties and characteristics, manufacture and probable conditions of exposure, toxicology, precautionary measures, and a bibliography. The work was prepared by Phillip Drinker of the Harvard School of Public Health and was reviewed by Dr. Baird's committee.

(Drinker, Phillip, *API Toxicological Reviews on Naphthenate, Naphthalene, Naphthenic Acids, and Butadiene*, American Petroleum Institute, 50 West 50th St., New York 20, N.Y., 25 cents.)

Use Readers' Service Postcard, Page 467, for More Information on Advertised Products

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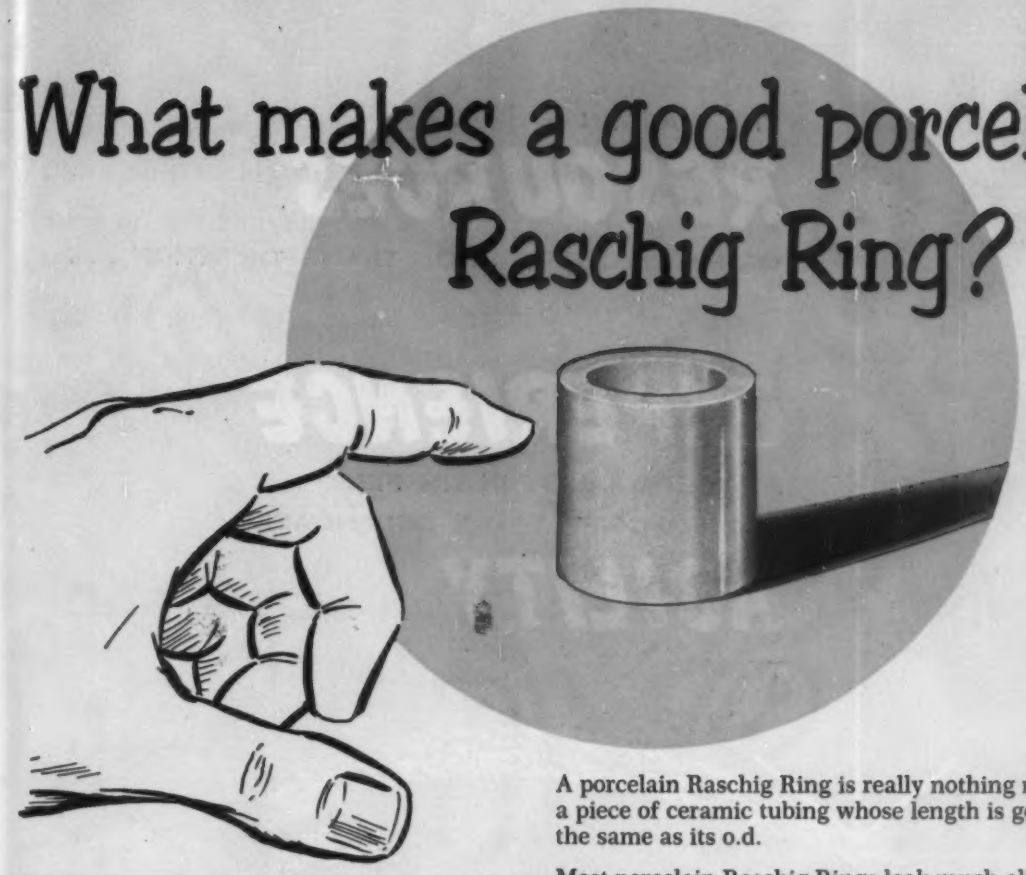

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- ☐ Bulletin TA-30. How to select and install Support Plates and Distributors.
- ☐ Bulletin HDP-56. The use and function of Hold-down Plates.
- ☐ Tower Packings and Packed Tower Design. 232 page text book, written by Max Leva, and published by The U. S. Stoneware Co. It is available in a cloth binding for $8.50 per copy, and in a special paper bound edition for students at $3.50 per copy.

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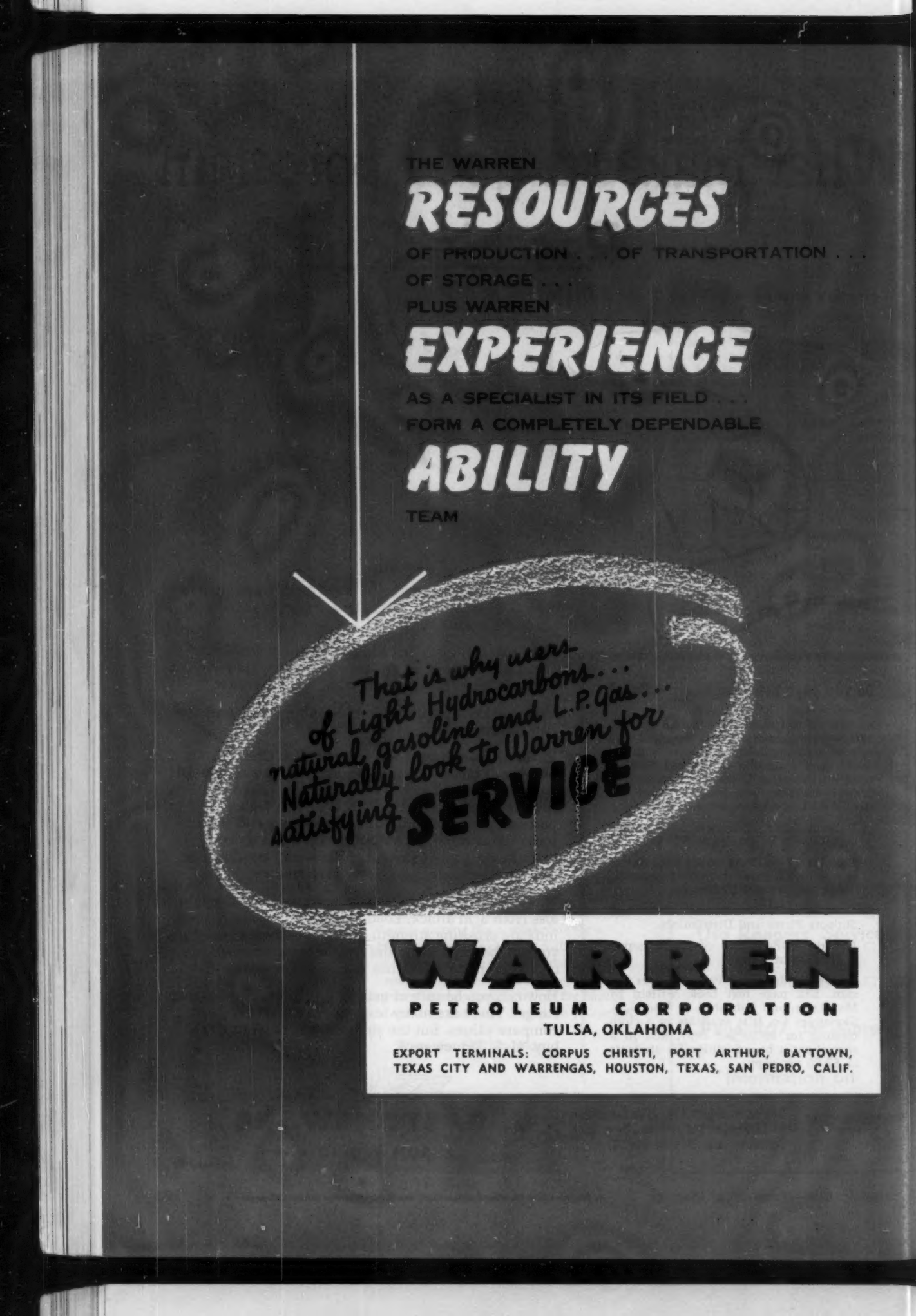
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Facts and timing are necessary for the birth of new and good ideas—and one of the best "idea-reactors" today is the meeting. Meetings can produce a chain reaction of creativity—providing they are handled right

Idea Acceleration—Key to Progress

E. Finley Carter
Stanford Research Institute, Menlo Park, Calif.

"NOW, THERE'S AN IDEA!"

You hear this exclamation every day, sometimes many times every day. But did you ever stop to wonder, what *is* an idea? How do new ideas get born? Do they come to us through flashes of pure inspiration, or are they, rather, the result of cold, deliberate thought? And finally, does man hold it within his power to control the generation of ideas to stimulate their flow?

This, I suggest, is a vital question, for in the last analysis, the progress of the human race depends upon ideas—good ones, and a plentiful supply of them.

At first glance, ideas may appear so abstract as to defy definition. On second look, however, we can agree that all ideas derive from facts, either known or suspected. And if we look deeper we can agree further, I think, that the essence of an idea is the sensing of the value or potential good that can come from taking advantage of new relationships between facts.

Enter the Wheel. In primitive times, the body of man's knowledge was relatively small, compared to what it is today. There were fewer facts, and hence fewer ideas that men could come up with. Let's look at a hypothetical illustration: the wheel. We can imagine, without taking too many liberties, that the wheel evolved from the discovery that round logs could be placed under heavy objects to move them.

One day, perhaps, a tribesman lacked the necessary space to place a full-length log under the object he wanted to move, so he shortened it. From there on, it was only a matter of time until someone tried a thin cross-section of a log, and the wheel was invented. You might say that the wheel was discovered almost by accident. But was it? It was known that logs moved objects. It was suspected that the thin cross-section of a log could better move objects. A new relationship between facts. An idea. And it worked!

Today, the wheel is doing all kinds of jobs which would completely mystify its inventor. Since that great discovery, whole new worlds have been added to man's store of knowledge and information. I suggest that it must have been a very hard thing indeed for a man to have invented the wheel long thousands of years ago, because he didn't have many facts to work with. I suggest that he must have been a real genius.

More to Work With. What about the people today who are thinking up new uses for wheels? And of the inventors of those complicated pieces of machinery and equipment which dominate our lives. Are they geniuses? I don't think they are, necessarily. Ideas come to them much more readily than they did to our friend who invented the wheel. There are so many more facts available, and a consequently greater number of possible relationships between those facts.

An oil refinery is a vastly complicated-looking operation, whose development was one of transition, improvement and new processes based on the know-how of a great many people. But was it as hard to develop as the wheel? I think not.

Look at it against the need, which arose only at the point that oil became a critically important material, without which the machine age could not operate. Look at it against the background of the technology of the times, which was considerable. With-

out depreciating the work of its many inventors, I suggest that putting an oil refinery on stream is perhaps an easier invention than the wheel. This is because it takes place at a point in history when there are plenty of facts to choose from and an excellent reservoir of engineers and scientists to improvise or invent on demand, and a clearly visible benefit from the result.

Facts Beget Ideas. Timing, then, is important in the development of ideas. Ideas cannot occur until the background of facts is established. And they cannot come into their own until their value is clearly applicable to existing technology. New ideas are new implications in facts—new uses which develop as technology develops.

But must we just sit around and wait for ideas to occur? Or is there something we can do to nurture them along? I think there is. I suggest that we can accelerate the birth and development of ideas by deliberately bringing together facts which would otherwise come together only by chance. We can nurse them along deliberately, when otherwise they would have to take their chances in an environment which might or might not be conducive to their development.

In my youth, there were reputed to be a few sage-like professors, particularly in the German universities, who knew everything that there was to know. Even then, I was skeptical of this rather smug claim; but certainly such bragging today would be ridiculous. There isn't anybody today who can know everything, or even everything about a particular field like physics, or biology, or economics.

It has been said about the product of today's universities, that a man with a bachelor's degree knows a little about a lot, one with a master's knows a lot about a little, and the holder of a doctorate knows everything about nothing. While this is swinging to the other end of a nonexistent pendulum, it is nonetheless closer to our present situation.

A Specialized Era. We are, in fact, living in an age of specialists. Specialization is not only at its height—it is increasing. The specialists are the people with the facts. They are the people who must logically be expected to contribute to the development of new ideas.

But specialization, which is a by-product of our progress, has brought problems, too. There are many ideas which must transgress established fields of specialization. There is, today, an interdependence among men far greater than there has ever been before. The more specialized we become, the greater our reliance on others to do the jobs for which we ourselves are not equipped.

If we leave the specialist alone to pursue his chosen field, what are the consequences for the production of new ideas and new ways of doing things? I fear the tendency will be to put a brake on creativity; to abort many of the really important ideas which haven't yet been discovered. This is the threat of specialization and compartmentalization.

Meetings Vital. Perhaps the best hope for preventing the atrophy of ideas, for insuring a continuing idea-flow, is to be found in the meeting. Yes, the plain old much-maligned meeting. There are those who would shrink at this, but I am going to stick my neck out and say that meetings are a good and necessary thing. Not that I mean all meetings are good. Many of them, in fact, are a waste of time and energy. But I am convinced that today, the meeting which brings together the many skills necessary to the development of our twentieth century ideas is the very front line of our assault on the future.

I am not about to advocate more meetings, nor am I going to suggest, simply, that from now on we need to have more creative meetings. But since the meeting is so often the place where ideas are expected to take form and substance, I am going to suggest that we need to take a careful look at the kind of meeting which best produces creative thinking.

The key to this kind of meeting, I think, is the moderator. Meetings are held to tell the participants something. Too often they are vehicles for an overinflated ego, for just plain gossip, and so on. They do not have to be. A proper meeting should be an "idea reactor"—one which demands of each participant his best creative thought.

A properly moderated idea falling upon the minds of others can produce a chain reaction so profound that history itself is changed. New products, higher standards of living, and new social structures are among the isotopes of chain reactions originating in an "idea reactor," be it a bull session, a seminar, or just a purposeful discussion between two or more interested people. Such reactors are most effective when the community of interests of its components is such as to cross-fertilize and stimulate each other's thinking.

Free Flow. An example of a productive meeting is one resulting in an exchange of experience and observation of scientists and engineers pursuing a course of investigation. I recall such a meeting immediately following the announcement of the transistor. It was comprised of about a dozen men who had been working on solid state devices and their applications. Such a free flow of ideas resulted that more new disclosures of inventions were made at this meeting than had been filed by this group in the preceding year.

Such meetings are all too rare. But I believe they can be made more frequent. A few more devoted to effective cross-fertilization, and we will have travelled closer to the goal of more effective use of our specialists. One wonders, for instance, whether we really have a shortage of engineers today, or whether the problem isn't more properly a question of getting the most out of the engineers we have, by just this process of idea stimulation.

Accept the Challenge. To the participants of today's meetings, and to those who will participate tomorrow, this is the challenge. Make meetings into idea reactors. Moderate them so as to get the most out of each participant. Stimulate your own creative

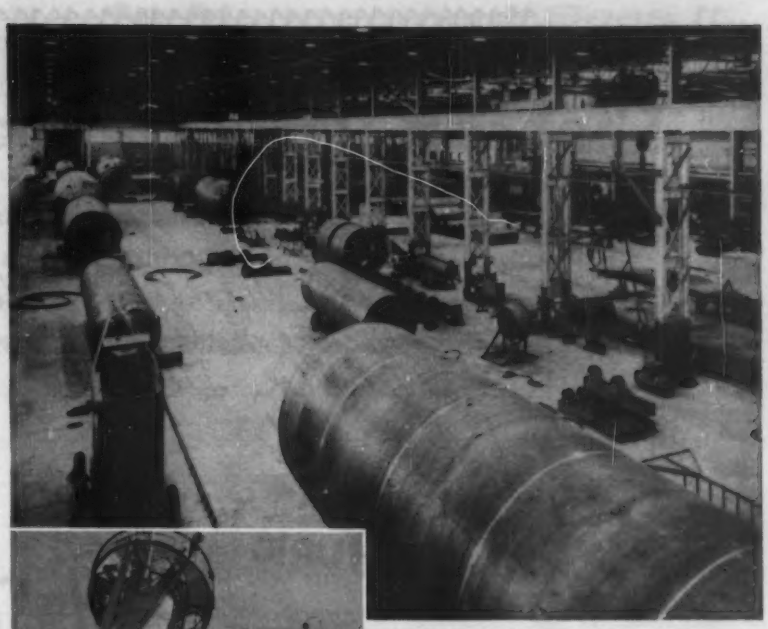
energies and those of your fellows. Think of every problem in the light of what you can contribute to it—what facts you can bring to bear so that new ideas will result.

No one of us could singlehandedly develop a missile, a high-speed computer, or a refinery process control system. But each can help to do greater things. No one of us can bring forth singlehandedly the solution to the world's social problems, but each of us can subscribe to a few basic objectives and so focus his thoughts and efforts as to accelerate his own ideas to a point where they dislodge others and help produce a chain reaction toward the achievement of these common objectives.

When we learn how to make our meetings into more perfect "idea reactors," I am convinced that the chain reactions produced will release the tremendous emotional and spiritual energy within us in a way which will achieve our highest hopes for the common good.

About the Author

E. Finley Carter is president of Stanford Research Institute, Menlo Park, Calif., and a member of the board. Holder of a B.S. degree in electrical engineering from Rice Institute, 1922, he began his career with General Electric Co., and joined United Research Corp. in 1929. In 1932 he went with Hygrade Sylvania Corp., where he was successively director of industrial relations, vice president in charge of industrial relations, vice president in charge of engineering, and vice president and technical director. Carter joined Stanford Research in 1954 as manager of research operations, became Institute director and a board member in 1956, and in 1959 was named president.



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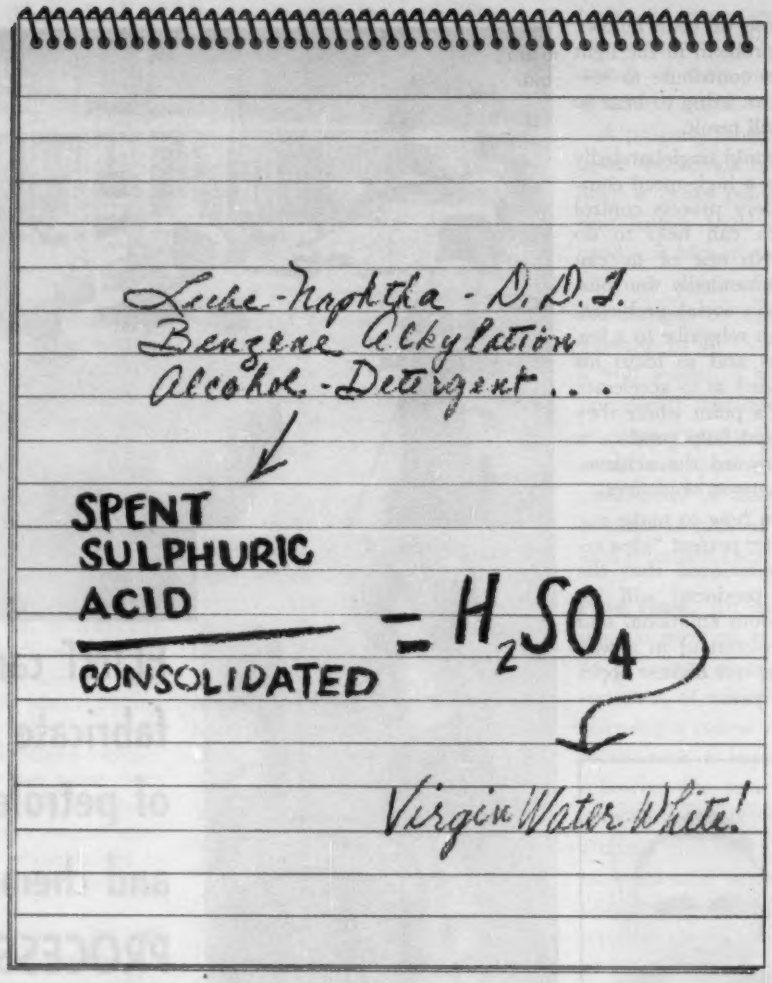

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Where Is Your Company Headed?

You should know where your organization will go—even if top management does not make any specific long-range plans. This is called the "momentum factor"—and here's how you can investigate it in full detail

Robert W. Schramm,
Southern Nitrogen Co., Inc.
New York, N. Y.

Use of long-range planning by U.S. businesses is estimated to have increased from 20 percent in 1953 to more than 50 percent today, with a much higher percentage anticipated for the future. Since application of this technique has grown so rapidly, there is much still to be learned about its various forms and factors. In this article, however, we will discuss only one important phase of long-range planning—the "momentum factor."

Long-range planning should answer for a company these five questions:

1. Where are we now?

2. Where are we going? (momentum factor)

3. Where do we want to go? (objectives and goals)

4. What is necessary to get there? (plans, programs)

5. What controls are required? (review, revision)

Company inertia. To do any long-range planning, it is necessary to have a complete understanding of the present position of the company, its purpose, resources, limitations, and aspirations. This answers the first question.

Following this, it is necessary to know where the business will probably go if no particular plans other than existing ones are contemplated. This is called the "momentum factor."

It is easy to see that a study of this momentum factor could in itself present a picture of the business perhaps as far as five years into the future. Many construction programs that are now being approved will be two to three years before completion, and it may take another two or three years for these plants to reach capacity. This expected expansion, plus probable growth of other existing facilities will give some idea of a five-year plan.

Depending upon what the goals may be, it is entirely possible that in some companies this analysis would show that no additional projects would have to be undertaken in the next several years. This momentum factor will be investigated in more detail.

Other answers. Before delving into this problem of the momentum of an organization, let's first answer the remaining three questions of the original five. These three questions will be considered briefly, however, this should not be taken to mean that they are unimportant. It is in these three questions that the long-range plan of a business is actually established and operated.

In the third question, "Where do we want to go?," the objectives are intangible, while the goals are tan-

Long-Range Planning—Area Responsibility Chart

NUMBER KEY
1—Major Responsibility
2—Secondary Responsibility
3—A Consulting-Advisory Responsibility
4—A Liaison, Collector, Coordinating Responsibility
5—A Supplier of Supporting Data

Key	Area of Long-Range Planning	ORGANIZATIONAL LOCATION				
		Chief Executives And Board	Finance Committee	Long-Range Planning Group	Operatign Manage-ment	Various Staff Groups
I	Statement of Business Purpose	1	2	3	2	2
	Audit of Resources and Limitations	1	2	2-3-4	1	2-5
II	Economic Forecasts (Total Economy and Corporation)	..	..	3-4	..	1
	Forecasting Form and Techniques	..	..	1	..	2
	Operating Companies Volume Forecasts (Units and Dollars)	..	..	3	1	5
	Operating Companies Profit Forecasts	..	..	3	1	5
	Construction—Research Related to Operating Units	..	3	3	1	5
	Summation to Total Corporation (Volume and Profit)	1	..	3-4	..	5
III	Total Corporation Objectives and Criteria (Volume Profit, Investment)	1	2	3	..	2
	Operating Companies Objectives and Criteria (Volume Profit Investment)	2	..	3-4	1	2
	New Concept of the Total Corporation	1	2	3	..	2
IV	Functional Planning and Programming (Financial, Research, Marketing, Raw Materials, Personnel, etc.)	2	2	3	1	1
	Product Programs to Achieve Objectives	2	2	1-3-4	1	2-3
	Research Programs for Growth	1	..	2-3	2	2
	Pattern Total Future Operations	1	2	3	..	..
IV-A	Acquisition Activities (Commercial Research, Selection, Negotiations, Integration, etc.)	1	2	1-3-4-5	1	1-3-5
V	Periodic Review and Revision of Objectives, Criteria, Plans and Programs	1	2	1-3-4	1	1-5

FIGURE 1—Abbreviated responsibility chart which answers the questions, "Where are we now?" and "Where are we going?"

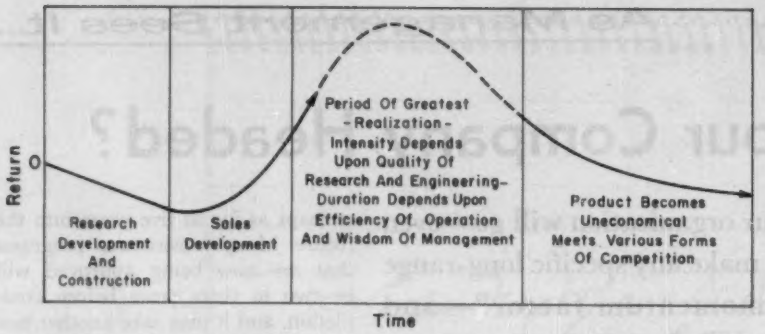
Return
0
Research Development And Construction
Sales Development
Period Of Greatest -Realization- Intensity Depends Upon Quality Of Research And Engineering- Duration Depends Upon Efficiency Of Operation And Wisdom Of Management
Product Becomes Uneconomical Meets Various Forms Of Competition
Time

FIGURE 2—This is the general pattern of investment return which an organization can expect from a new product.

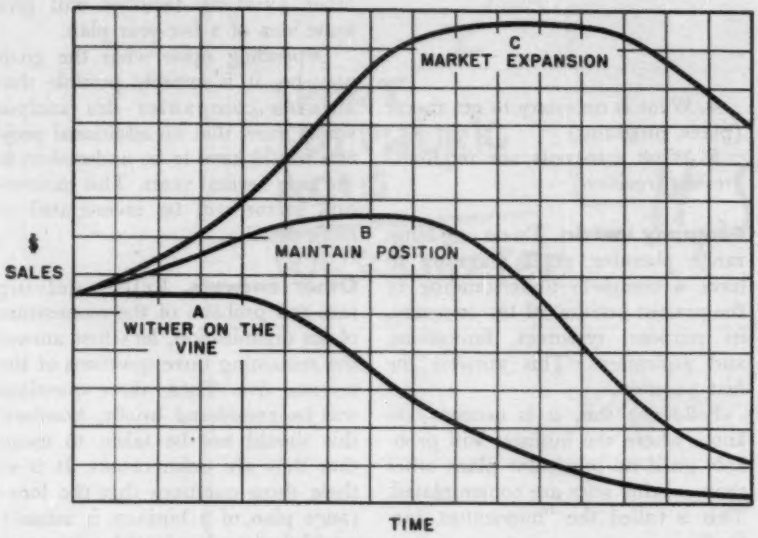

FIGURE 3—Here are the three general strategies which can be followed when dealing with products already on the market.

gible. The term "criteria" is considered as the yardstick that sets the units of measurement for the objectives and goals.

The fourth question, "What is necessary to get there?," has a distinction between plans and programs. This distinction is that a plan becomes a program when it is defined in terms of time. It is also in answer to this question that possible acquisitions are considered. In some companies the long-range plan will consider the necessity of an acquisition in order to achieve market participation, diversification, or a toe hold in a new growth area.

The last question, "What controls are required?," provides for review and revision. If properly done, a long-range plan clearly spells out what is anticipated so you will know when the plan needs revision because the actual events are not following the prediction. Thus, long-range planning becomes a progressive action that keeps the managers ahead of the needs of the business and working toward realistic objectives and goals.

Who is responsible? The first question is, "Where does the responsibility for long-range planning lie in business?" Without a doubt, it lies with top management because it is a policy decision. However, other people in the corporation must be consulted and their work coordinated into this long-range plan.

Figure 1 shows in abbreviated form who is responsible for answering the first two questions. Certain people have major responsibilities, other secondary responsibility, others have a responsibility for coordination, others for consulting and advising, while still others have only a responsibility for supplying supporting data.

Of course, this responsibility chart will act only as a coordinator. It must be supported by other schedules and checklists for each of the required sub-areas.

The question which follows who is responsible, is the question of what things require planning. By a bit of fancy alliteration, these are called the "seven M's of business." Namely, these are:

1. Men
2. Money
3. Markets
4. Materials
5. Manufacture
6. Management
7. Motivation.

If you care to break down manufacture into machines and methods, there can be eight "M's." While this article will not go into review of these items, any long-range plan should cover each area. In evaluating the momentum factor of a business, it is necessary to decide where each of these items stands and how it will develop.

Product expectations. In any long-range plan the most important single projection is that of the sales pattern. All present products can be expected to have some sort of life expectancy, and all products usually will follow a general pattern. There is a well-known phrase in the chemical industry of "seven years from test tube to tank car." Figure 2 shows the general pattern of investment return in a new product.

From its research and development stage and on into the construction of the plant, it actually has a negative return. When the plant is constructed and sales development begins, the product begins to make a positive contribution. Eventually it breaks even and begins to return the money that has been paid into its development.

Next follows the period of greatest realization, in which the intensity of the return depends upon the quality of the research and engineering that has gone into the product. The duration of the return depends upon the efficiency of the operation and the wisdom of management in its choice of products. However, all products usually reach a stage where they become uneconomical because they meet various forms of competition or are displaced in the market.

Product life. Although "seven years from test tube to tank car" is

generally accepted, the time duration following the tank car stage has no set pattern. However, with present products there are usually three strategies that can be followed. In Figure 3 you can see the three general strategies available. The first strategy is allowing the product to "wither on the vine," i.e., no money will be put into the product, but the present capacity will be maintained as long as possible. As the sales die, the product will also die.

The second is the "maintenance of a position." In this strategy, management anticipates there will be some sales growth left in the product and that capacity sufficient to maintain the company's market position will be constructed; but eventually the product will drop off. The difference between strategy "A" and strategy "B" is that "B" reaches a somewhat higher peak and has a more prolonged return from the production facilities.

In the remaining strategy "C," research and development money is put into the product for market expansion. Money is spent studying the process in hopes that production economies can be realized, thereby prolonging the market by having a higher return, or expanding the market by lowering prices. There is always the hope, however, that R & D money will increase both the volume and durability of the market.

Which strategy? With present products it is possible to follow any of these strategies. Generally, management would prefer to follow strategy "C" and expand the market. However, it is necessary to evaluate very carefully whether the additional money spent on research and development will favor market expansion. It is entirely possible that a marginal or submarginal situation may come into being in which a dollar spent on market expansion will not yield as much return as if it were invested in an alternative strategy upon another product.

In determining which strategy should be followed, there are two other elements that should be considered. The first is profitability, and the second is probability. There has been a series of discussions about how to measure profitability, but this is not properly a subject of this article. The important matter in profitability in long-range planning is consistency. Whether profitability is measured by payout period, pro forma payback, return on investment, discounted cash flow, or net present worth, consistency is paramount.

Since there is no riskless action in business, probability should be assayed on each action. The probability consideration should be that research will yield a new use or a new process. This should be balanced against the probability that the same effort and money applied to another product might yield equal or greater results with a higher degree of certainty.

Background material. In the production of the momentum factor, the total situation of the company will be subdivided into smaller units, and generally the final planning will concern only a single product or a group of closely related products. There will be two items which will serve as background for all the planning:

1. The assumed economic, social, technological, and political factors that affect the long-range potential of the business.

2. An analysis of the total indus-

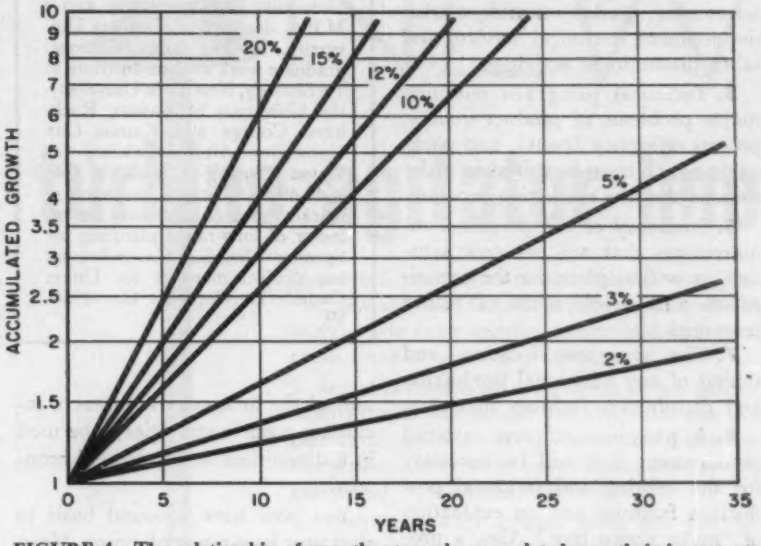

FIGURE 4—The relationship of growth-rate and accumulated growth is important. For instance, with a three percent growth, your company will double in size in about 24 years.

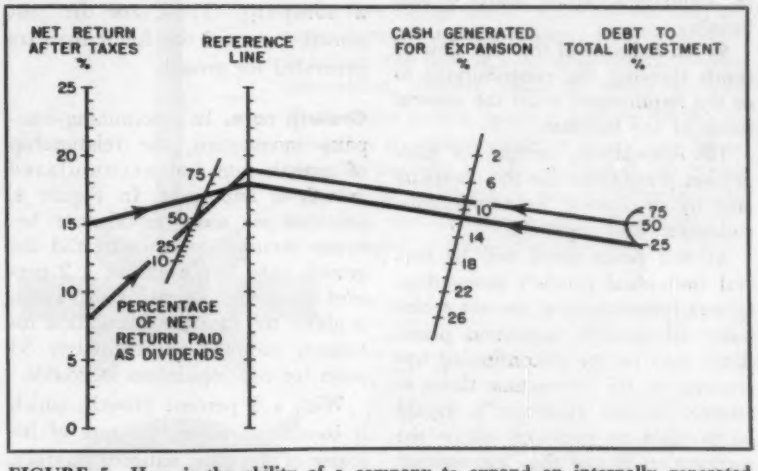
NET RETURN AFTER TAXES %
REFERENCE LINE
CASH GENERATED FOR EXPANSION %
DEBT TO TOTAL INVESTMENT %
PERCENTAGE OF NET RETURN PAID AS DIVIDENDS

FIGURE 5—Here is the ability of a company to expand on internally generated capital and how this growth is related to present financial structure and operation. For instance, if a company is producing a 15 percent return, has a policy of paying out 65 percent of its net returns as dividends, and maintains a total investment that is 25 percent debt, then this company can expand at an annual rate of 11½ percent from internally generated cash.

try as to market potential, price trends, and the competitive situation.

In the specific product programs, the major items will be:

1. Present status of the product, size of markets, expected ultimate market, rate of market growth, competition, price structure, stability and probability of product obsolescence.

2. The company's present market share and sales volume, and an estimate of maintaining or increasing this position at future price levels.

3. The future program estimating sales, production costs, profits, and degree of risk involved.

4. Marketing program for sales, advertising, market research, market development, technical service, and other promotional activities.

5. Technical program outlining major problems of product quality, process efficiency (costs), and packaging which must be solved in order to meet the new marketing program.

6. Summary of the personnel requirements that are not now satisfied, as well as plans for the organization and development of future personnel.

7. The size, cost, location, and timing of any additional production and distribution facilities necessary.

8. A program of raw material procurement that will be necessary for the existing and proposed production facilities and an evaluation of "make versus buy." Also, a program for assuring stability of supply by having more than one supplier and/or a captive source of materials.

9. An estimate of the cash flow of funds showing the contributions to or the requirement from the general funds of the business.

10. Acquisition, merger, or integration possibilities for the company and by or among its competitors, customers, and suppliers.

At this point there will be several individual product momentum factors, however, these are not necessarily all positive expansion plans. Some may be for discontinuing operations or for converting them to alternative uses. However, it should be possible to picture where the corporation is and the "momentum factor" of where it is going under the assumptions made. The completed plan must include possible alternative strategies and an evaluation of the inherent risk of each, including possible strategies to be used in a diminished or accelerated economy.

You now have a sound basis to start your long-range planning. However, there are two other points that have bearing on the momentum of a company. These are the past growth rate and the funds that are generated for growth.

Growth rate. In determining company momentum, the relationship of growth rate and accumulated growth is important. In Figure 4, you can see some significance between accumulated growth and the growth rate. For example, a 2 percent compounding per year, which is about the rate the population increases, requires approximately 35 years for the population to double.

With a 3 percent growth, which is considered about the rate of increase of the gross national product, the doubling takes place in approximately 24 years. With a 5 percent growth, considered the rate of improvement in agricultural productivity, doubling takes place in about 14 years.

If you take the traditional growth of the chemical industry as being 10 percent per year, you see that the doubling has been taking place about every 7½ years.

If you choose for your company to grow at a rate faster than the industry itself as, for example, 12 percent, this means that you are asking for a doubling in size of the company each six years. If you wish to grow 50 percent faster than the indutry, or 15 percent per year on a compounding basis, you are asking your company to double in size every five years. This is important for it shows what it takes in the way of growth to increase or maintain the momentum of the business.

Expansion capital. Figure 5 defines the ability of a business to expand on internally generated capital and how this growth is related to the present financial structure and operation. In constructing Figure 5 certain simplifying basic assumptions were made.

The turnover rate has been taken as 1. This makes the return on investment and the return on sales the same, and eliminates the necessity of choosing rate of investment increase or rate of sales increase as a criterion for growth since they will be the same. Annual depreciation is straight line at 6.6 percent (15 years) and the debt is retired in equal sinking fund payments over 25 years. The capital available for expansion is the total of the after tax income, less dividends and debt retirement, plus net depreciation. It is possible to construct such a chart that will apply to the conditions of turnover rate, debt and equity ratio and dividend payout of any company.

If, for example, a company is producing a 15 percent return and has a policy of paying out 65 percent of its net return as dividends while maintaining a total investment that is 25 percent debt, then this company by internally generated cash can continue to grow at about 11½ percent per year.

If, on the other hand, you are a company with an 8 percent rate of return, a 50 percent dividend policy, and 50 percent debt, then you can expand at a rate of 8½ percent from

About the Author

Robert W. Schramm is general manager of development for Southern Nitrogen Co., Inc., New York. He specializes in long-term corporate planning and evaluation of new business opportunities. Schramm has a B.S. degree in chemical engineering from the University of Notre Dame and a M.B.A. degree from Indiana University. He has done additional graduate work at Case Institute of Technology, New York University, the University of Kansas, Rockhurst College and Kansas City University. After working for Union Carbide Chemicals Co., 1944-49, he became manager of market research, and later coordinator of long-range planning for Spencer Chemical Co. Schramm was project manager for Union Carbide Development Co., 1956-59.

internally generated funds.

You may also use such a chart in the selective screening of projects and as an aid in the establishing of fiscal policies. Also, you may evaluate arbitrarily selected goals against such a chart to make certain that they do not demand highly improbable performance for their accomplishment.

Long-range planning is not a "one shot" operation which is established and remains in its initial form for years to come. It must be a flexible, dynamic program which is constantly scrutinized and adjusted to logically allocate the resources of the business to permit them to be increasingly placed in attractive areas while withdrawing them from unsatisfactory sections. Such a program is of utmost importance to a company. It should yield returns which make its expense insignificant.

This has been a brief attempt to show how the "momentum factor" is obtained, why it is important as a basis for long-range planning and to show some simple tools of measurement. Here's hoping it will generate sufficient interest so that you will try the concept and refine and improve upon it.

(Originally presented before the American Institute of Chemical Engineers, Cincinnati, December, 1958).

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The Hazards of Static Electricity

Many disastrous fires and explosions have been attributed to static electricity. These principles, however, will help you understand the methods of static protection—and the problems that accompany them

John C. Howard
Standard Oil Co. (Indiana)
Whiting, Ind.

STATIC ELECTRICITY is a hazard in the petroleum industry because it is inherently generated in the manufacture, transporting and marketing of highly refined flammable liquids. A number of disastrous fires and explosions have been attributed to static electricity in handling petroleum products.

Although many individuals have been exposed to electrostatics in an academic way, such knowledge grows rusty with disuse. Therefore, this refresher of principles for those who have studied the subject as well as for those who have not, will aid directly in understanding the problems and methods of static protection that follow.

Principles of static electricity. Static electricity is a phenomenon that is familiar to everyone. It was known 2500 years ago to the Greek philosopher Thales who knew that amber after being rubbed would attract small objects. At about the same time, shepherds in the province of Magnesia discovered the property of magnetism when certain small black stones were attracted to nails in their shoes.

Today students are introduced to the subject by such simple experiments as producing a charge by rubbing a glass rod with wool. They are told that wool takes on a negative charge because it has rubbed electrons off of the glass rod. Actually the true nature of the generation of static electricity is not known even in this simple experiment. The secret of generation is locked in the inner most structure of matter, and in spite of modern research we know little more about it than Thales and the Shepherds.

However, we do know how to build machines to generate electricity and how to deal with electricity from these machines in a multitude of applications. We can shut down man-made electric generators if we wish to stop the generation of electricity. However, we do not know how to control the generation of static electricity originating in the structure of matter.

It would be a simple cure to our static problems if we could stop generation at its source. As we continue, you will understand why we have not progressed very far in solving some of our static problems. In some instances we do not know what to do with the static electricity even after it is generated.

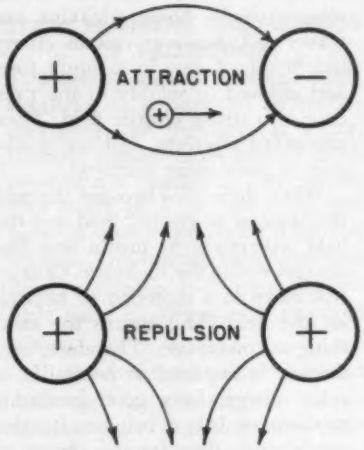


FIGURE 1—Arrows show conventional directions of electric field.

Nature of the charge. A charge is not material particle but a force. However, a material particle may possess the property of charge. A good example is the electron which is a material particle with a negative charge. Charge may be considered as that force which creates an electric field. Charge may be generated in these several ways:

1. Friction between unlike substances followed by their separation, as in static electricity.

2. Electro-chemical reactions, as in primary batteries.

3. Movement of a conductor across a magnetic field, as in electric generators.

4. Thermo-electric effects, as in thermocouples.

5. Photo-electric effects as in an "electric eye."

In each method of generation an electric field is created and charged particles within the field will move if a conducting path is provided.

Electric charges may be positive or negative, positive charges being those which move in the direction of the electric field. A "free charge" is the type of charge found in conductor and one that is free to move when an electric field is applied. A "bound charge" is the type of charge found in an insulator and is not free to move, or it is a charge held in place by another charge of equal intensity and opposite sign.

Charged bodies. Figure 1 illustrates two charged bodies. The ar-

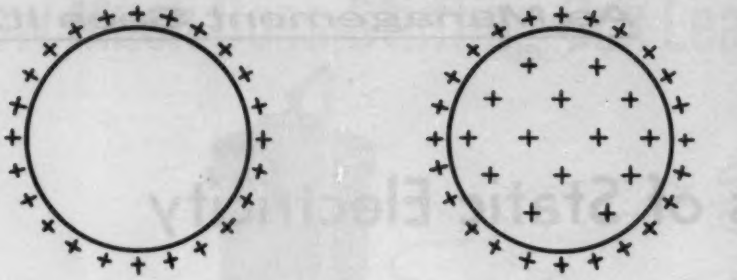


FIGURE 2—Both metallic bodies and insulating bodies can become charged.

rows show the conventional direction of the electric field. The electric lines of force are leaving the positively charged body and entering the negatively charged body. A positively charged body in an electric field will move in the direction of the field. Like charges repel and unlike charges attract.

Both metallic bodies and insulating bodies can become charged as shown in Figure 2. The charge resides on the surface of metallic bodies and is zero at all points inside. For insulators or dielectrics, as nonconductors are called, the charge is distributed through the interior as well as on the surface.

In Figure 3a, the conducting body may become charged by conduction if it is brought into direct contact with mobile charges, provided the body is insulated from the earth. Figure 3b illustrates that a grounded conductor cannot accumulate a charge because the charge will drain off to earth.

Figures 4a, 4b, 4c and 4d show how a conductor insulated from earth can be charged by induction. A positively charged body "A" is brought near a conducting body "B" thus attracting negative charges to the nearest side of the body and repelling positive charges to the far side of the conductor. If the charged body "A" is removed, the separated charges on body "B" re-unite and the charge returns to zero.

However, if the charged body "B" is first momentarily grounded, negative charges will flow from the earth to body "B" neutralizing the positive charges and the bound negative charges will be held in place by the presence of body "A." If body "A" is removed, the negative charges are trapped on body "B" which then becomes negatively charged. This is known as charging by induction.

Insulators. Being nonconductors, insulators cannot be charged by conduction. They can, however, be charged by friction or induction.

If a positively charged body is brought close to an insulator or in contact with it, the insulator will be attracted. This happens irrespective of the polarity of the charged body. This is explained by the elastic dislocation of "bound" charges in the insulator, called "polarization."

In this instance, the insulator exhibits the properties of a negatively charged body but the charge returns to zero with the removal of the charged body. Some plastics and waxes will, however, retain charge indefinitely if cast in a liquid form and allowed to solidify in the presence of a strong electric field. These are called electrets, and are analogous to permanent magnets.

When dielectrics become charged, they possess an electric field and this field attempts to move any free charges within the dielectric. Charges will move in a direction to neutralize the field. This means the same thing as conduction. Therefore, conduction is required to neutralize or relax charge. In a good insulating medium of large volume, it takes considerable time for the charge to relax and this is the situation with large volumes of dry refined oils.

Producing static charges. The fundamental process of generating a static charge appears to be the relative motion of two bodies of different substance in close association at their interface. The relative intensity of generation and the polarities developed will vary with the types of materials, the pressure of contact and the velocity of motion. Charges, although generated, will simultaneously leak away unless the materials are extremely good insulators permitting storage of charge.

Most static machines are actually not static generators in the true sense but simply mechanical devices that depend upon fundamentally generated static to get generation started, much the same as a direct

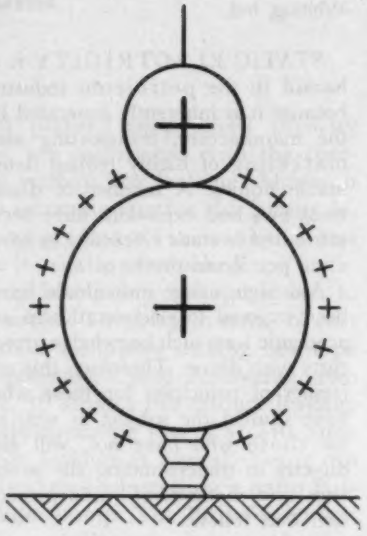


FIGURE 3a—Charging by conduction from a charged body.

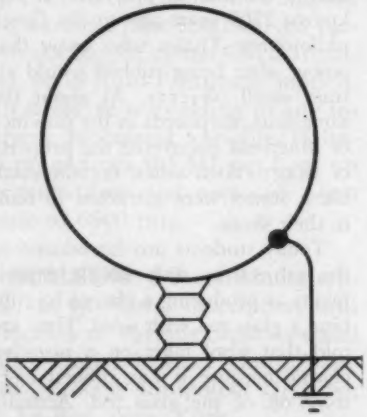


FIGURE 3b—Discharging by conduction to ground.

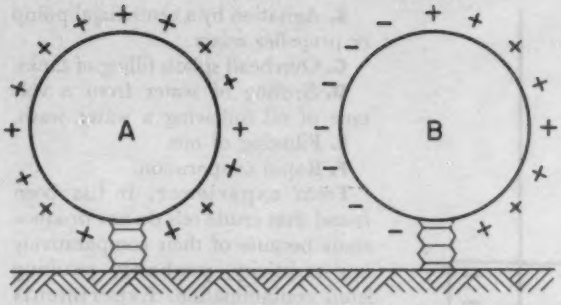


FIGURE 4a—Positive charged "A" attracts negative charge to near side of "B" and repels positive charge to the far side of "B".

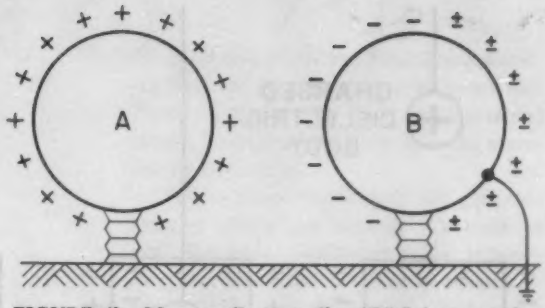


FIGURE 4b—Momentarily grounding "B" brings negative charge from the earth to neutralize the positive charge.

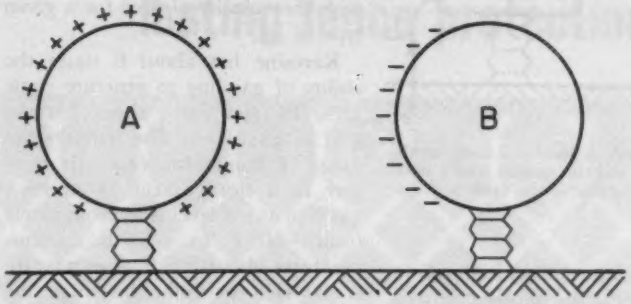


FIGURE 4c—With ground on "B" removed the remaining negative charge is trapped or "bound" on "B".

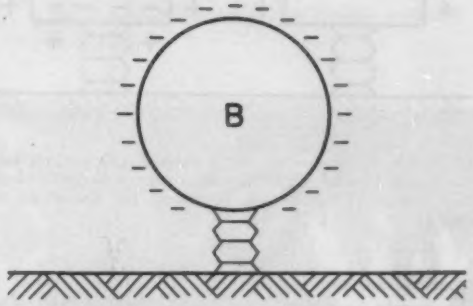


FIGURE 4d—Removing "A" leaves "B" charged negatively.

current dynamo needs residual magnetism to start generating.

The Van de Graaff generator is simply a belt conveyor of electric charges that may be sprayed onto the belt from any source of generation. This machine is made possible by the fact that the interior of a hollow sphere will accept any charge however small without regard to the total charge on the sphere.

Storing static charge. It has been said that the generation of static in itself is not hazardous; that the real danger lies in the accumulation of static because in this way enough energy can be stored to create a spark capable of igniting a flammable vapor-air mixture.

Electric charges are stored in a capacitor which is simply two conductors separated by a dielectric. The ability to store electric charge is known as capacitance. The energy in a capacitor is

$$W = 1/2\ CV^2$$

Where C = Farads, V = volts, W = joules. The minimum sparking energy to ignite hydrocarbon-air mixtures is on the order of 0.2 to 0.3 millijoules.

The common form of capacitor encountered in the petroleum industry is any type of container that is well insulated from ground. The container becomes one plate of a capacitor and the earth the other plate, with air as the dielectric between them. Good examples are cans or pails resting on insulating material or tank trucks on rubber tires.

Generally speaking, static must accumulate in a capacitor to provide sparks having sufficient energy to cause ignition.

STATIC PROBLEMS AND METHODS OF PROTECTION

1. Static from tire friction. Static electricity is generated by rubber tires rolling on highways. It is particularly noticeable on asphalt pavement in dry weather at high speeds. The body of a car or truck will store-up charge generated by tire friction. This has not been hazardous because charges leak from the vehicle quite rapidly after it comes to a stop.

In any event, the vehicle is always discharged by contact with an attendant prior to filling with gasoline. Drag chains were once thought to be necessary on gasoline tank trucks but have long since been found to be ineffective.

2. Static from belts. Static from flat belts is difficult to control with respect to the complete elimination of electrical discharges. Combs and similar devices have been used to remove charge from belts but such devices are not recommended in hazardous locations. Radio-active materials are sometimes used to ionize the atmosphere at the points of highest electrification on a belt to dissipate the static. For some reason, however, V-belts do not appear to generate dangerous amounts of static.

Conducting rubber is sometimes used for "anti-static" belts. This type of rubber has been found, however, to become non-conducting with use. Fortunately belt drives are not found necessary for many applications in hazardous locations. Belts can also cause friction fires. Consequently, the safest recommendation is to avoid the use of belts in hazardous locations when possible to do so.

3. Generated by steam jets. Static electricity is generated in wet steam exhausting to the atmosphere. The seat of generation is in the

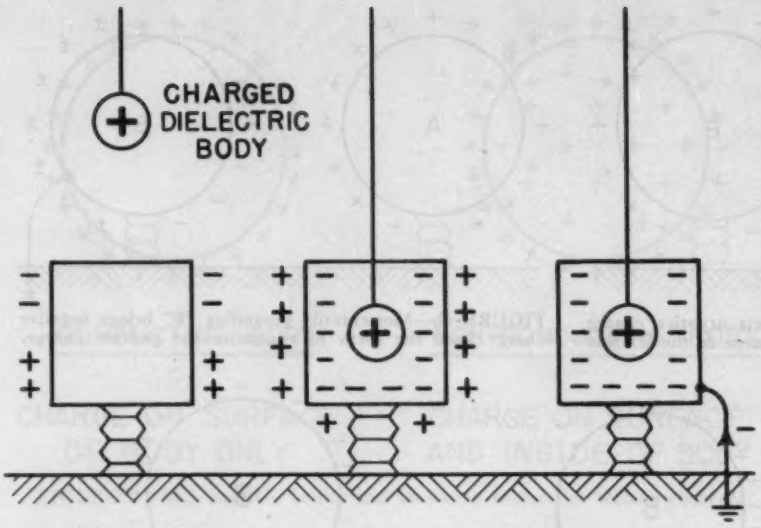


FIGURE 5—If the oil has a positive charge and the tank is insulated from earth, the inside wall of the tank will acquire a negative charge and the outside wall a positive charge. If the tank is grounded, the charge on the outside of the tank will disappear.

steam cloud not far from the end of the nozzle and is said to result from condensation. Any metallic object insulated from earth such as a truck can become charged if it is within the vicinity of the steam jet, and it is not necessary that the steam cloud strikes the object.

A hazard may exist where steam is used for tank cleaning or snuffing if there are metallic objects insulated from earth in the areas being steamed. Of course, these metallic objects must be close enough to a grounded object to permit a spark discharge to ground.

There has been some thought that steam clouds inside of a tank could cause a miniature thunderstorm in which electrical discharges occurred between clouds of steam. However, such a phenomenon is not considered likely on a small scale and has never been substantiated.

4. Manufacturing and handling petroleum products. Static generated by the manufacture and handling of dry refined flammable liquids is the industry's most hazardous and perplexing problem. It has been found that dry refined oils such as gasoline, kerosene, jet fuels and similar oils will become charged durthe following operations:

A. Flow through a pipe.

B. Agitation by a centrifugal pump or propeller mixer.

C. Overhead splash filling of tanks.

D. Settling of water from a volume of oil following a water wash.

E. Filtering of oils.

F. Rapid evaporation.

From experience, it has been found that crude oils do not produce static because of their comparatively low resistivity, probably resulting from contamination. Experiments show that oils must have a resistivity exceeding 10^{10} ohm-cm in order to generate static. Generation increases with the velocity of flow for a given type of oil.

Kerosine has about 6 times the ability of gasoline to generate static and JP4 (jet fuel) about 3 times that of gasoline. The temperature range of flammable vapor-air mixture in a storage tank of aviation gasoline at sea level is approximately from —50° F. to +30° F. At temperatures about 30° F., the mixture is too rich to ignite because the vapor formation would exceed the upper limit of 7.6 percent (by volume in air).

JP4, however, may form flammable vapor-air mixtures in a closed container in the range from —10° F. to +100° F. Consequently JP4 represents the most serious practical hazard under normal ambient temperature conditions that prevail in the United States.

When charged oil enters a tank, two electrical phenomena occur:

A. Assuming that the oil has a positive charge and the tank is in-

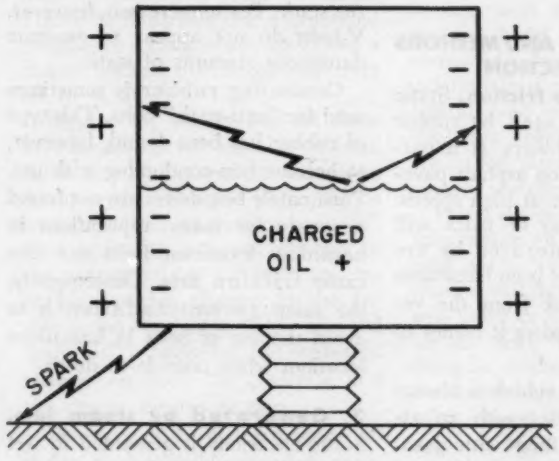


FIGURE 6—An oil tank insulated from ground may spark across the oil surface or from the tank to the ground.

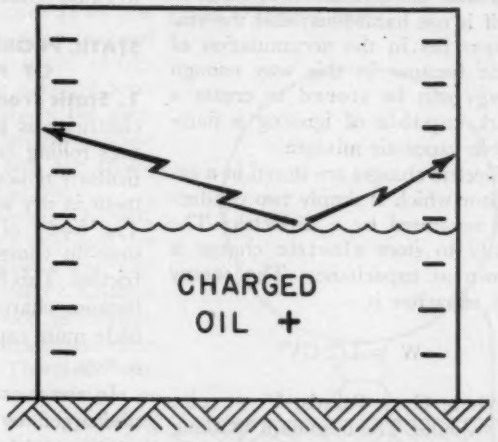


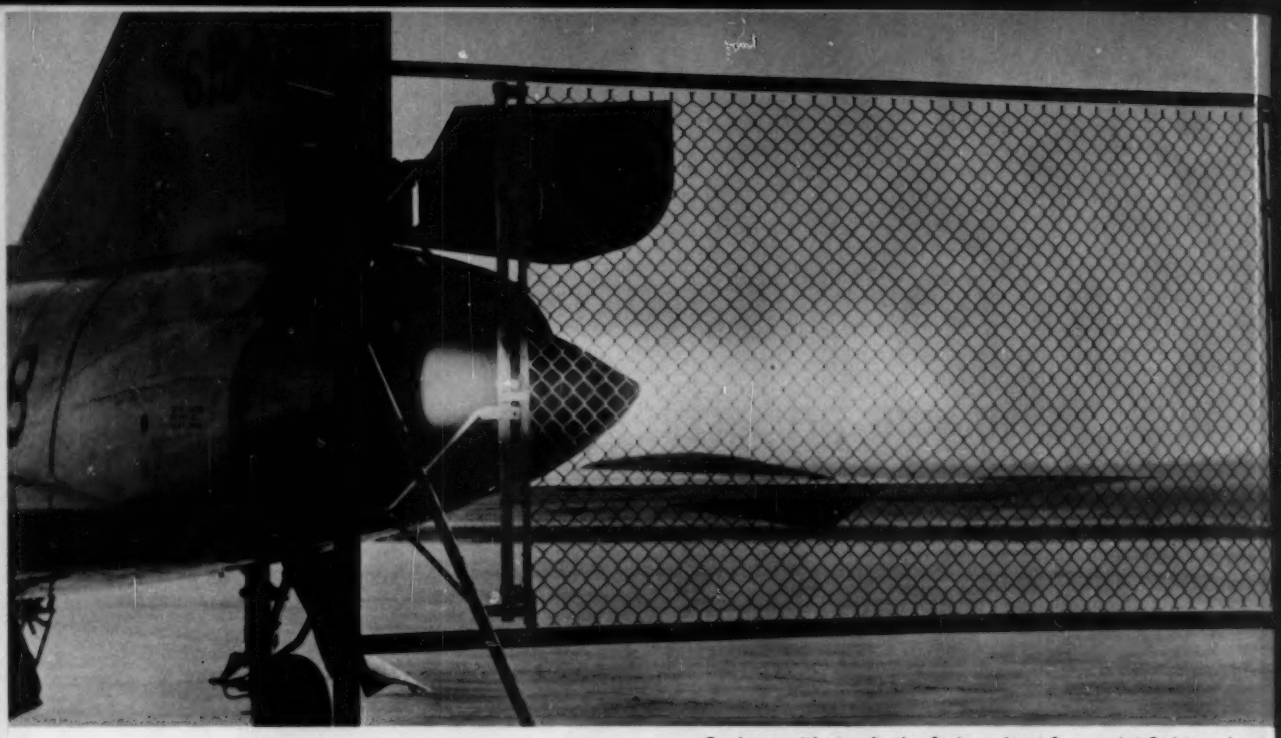
FIGURE 7—Charge on the exterior of the tank shell will drain to the earth when the tank rests on the ground. However, grounding of the tank has no effect on the oil surface charge inside.

How to give your property lasting fence protection

There are many Cyclone Fences now standing that are 30, 40 or even 50 years old. They control traffic daily at industrial plants, municipal projects, schools, warehouses and parks.

USS Cyclone Steel Fence can give this type of protection because it's built to last. The woven chain link fabric is heavily galvanized after weaving to resist corrosion. The posts are rugged. They won't heave with frost or fall with shock or impact. And the gates are balanced to open and close countless times without dragging.

For more proof of Cyclone's excellence, see what happened when special panels were subjected to gruelling tests.



Cyclone withstands the furious heat from a jet fighter plane

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4 tests that show why USS Cyclone Ste

Different situations . . . different tests . . . with the same result every time. Cyclone Steel Chain Link Fence can take punishment and come back for more. Fire and heat couldn't melt that heavily galvanized steel fabric. Highly corrosive salt atmosphere could not cause destruction, not in 10 years' time. Not even the

power
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. . . the shattering impact from a speeding 4000-pound car

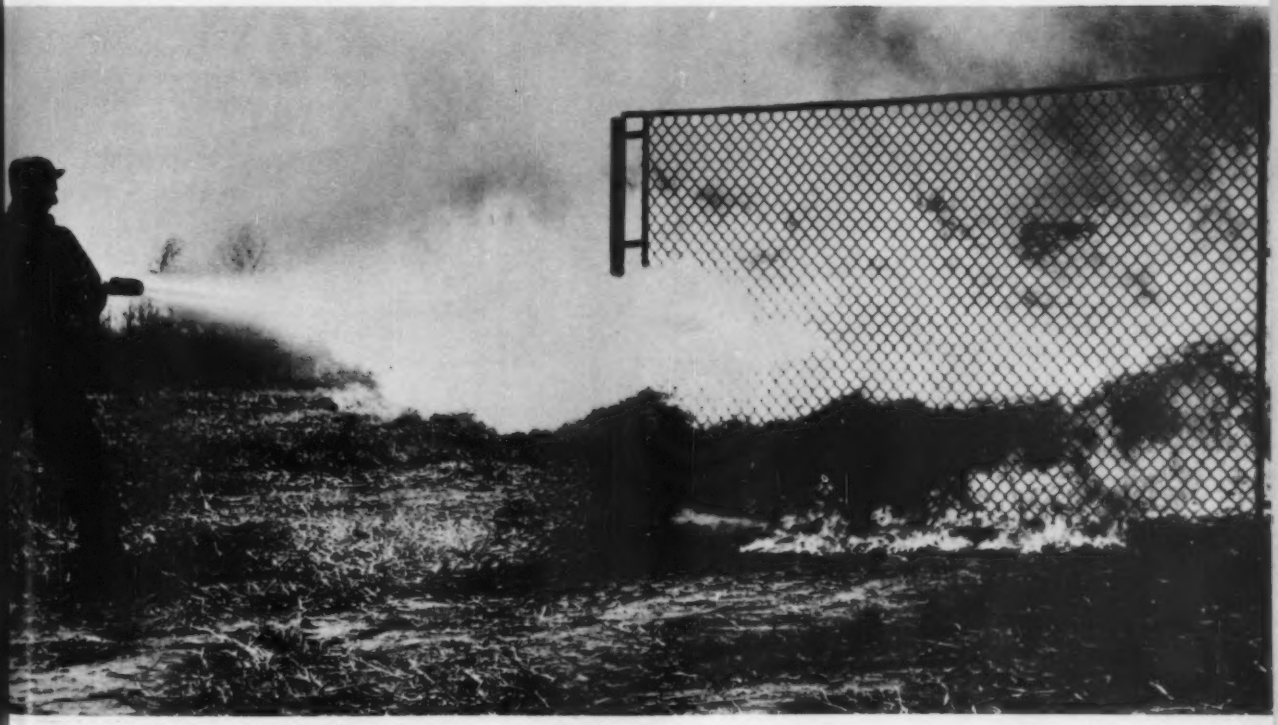
. . . sc

. . . ten years' exposure to corrosive salt atmosphere

Steel Fence is your best buy

powerful force of that hurtling car damaged the Cyclone Fence beyond usefulness.

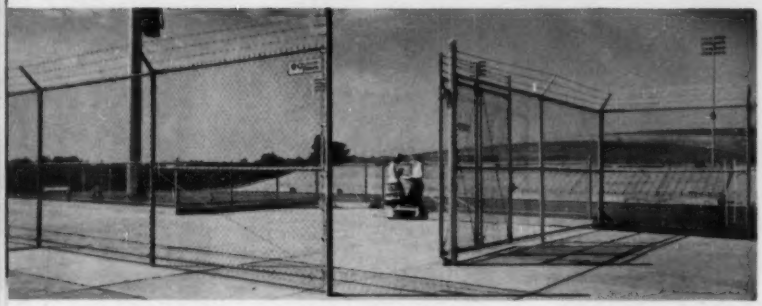
Isn't this proof that USS Cyclone Fence would be the best investment to protect your plant, school or other property?



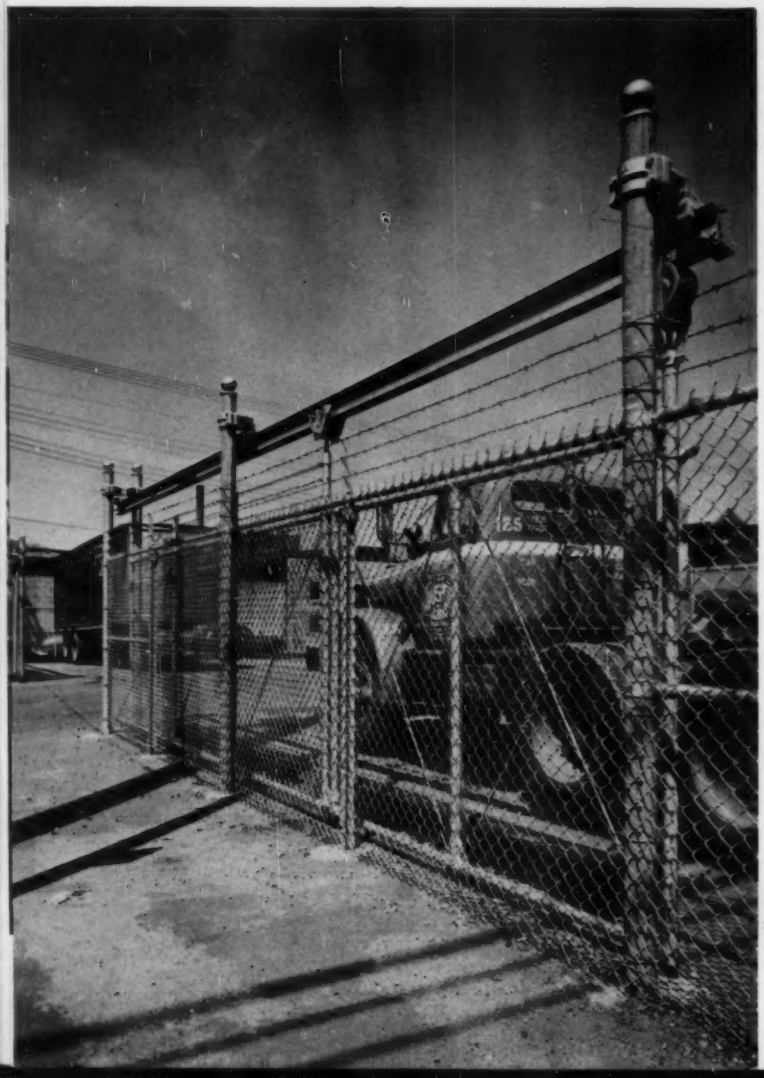
. . . scourging fire from a military flame thrower

Here's how others use the protection of Cyclone Fence

Where maximum security installations are required, such as around an atomic energy plant, special gates and electrical operating equipment can be provided to control traffic.



Cyclone Fence controls admission to athletic events and keeps out uninvited guests. It makes a safe playground for small children, protects them from the dangers of traffic and wanderlust.



Huge trucks roar in and out of this warehouse every day, and sometimes they sideswipe the fence. Yet, after long, hard service the fence is still in good condition.

whatever your fencing needs, USS Cyclone can supply them

Cyclone is the world's largest manufacturer of property protection fence. It has been the leader in producing quality chain link fence and in establishing proper specifications. Cyclone Fence is backed by all the research and engineering facilities of U S Steel. Remember this when you specify property protection fence. For more information, write to Cyclone Fence Dept., American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.

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sulated from earth, the inside wall of the tank will acquire a negative charge and the outside wall a positive charge. If the tank is grounded, the charge on the outside of the tank will disappear.

This particular phenomenon is explained by Faraday's ice pail experiment shown in Figure 5. It is the reason for grounding tank trucks and other types of containers during filling to prevent the possibility of a spark discharge to ground in the presence of a flammable vapor-air mixture.

B. The second phenomenon that occurs during the filling of tanks is the static charge that develops on the free surface of the oil. Figure 6 illustrates both the phenomenon of charge on a tank shell and the charge on the oil surface when a tank insulated from earth is partly filled with charged oil. The locations where sparks can occur are depicted on the oil surface and between the tank shell and earth.

Figure 7 illustrates that the charge on the exterior of the tank shell is drained to earth when a tank rests on the earth or is grounded. However, the grounding of the tank has no effect on the oil surface charge inside of the tank. This is the most serious static problem in the industry for firstly, it is difficult to find a method of protection that is generally applicable to all forms of storage, and secondly, the sparks occur in a location where ignition of flammable vapor-air mixtures is a possibility.

That more fires do not occur is probably because the sparks take place on the oil surface where the mixture is usually too rich to ignite.

Grounding effective. The first phenomenon, that of charging the container, is easily protected against by grounding. Most tanks in the industry are inherently well grounded. Only tank trucks, portable drums, and cans need to be grounded during filling. Low resistance to ground is not necessary because resistances as high as one megohm will drain off static charges on tanks. Therefore a bond or ground wire needs to be sized only for mechanical strength.

The second phenomenon, but the first in rank of importance, is the hazard of static sparks on a free oil surface. This phenomenon has caused fires and explosions in almost every phase of handling dry refined flammable liquids. Large cone roof storage tanks have exploded or taken fire shortly after pumping was started into the tanks. A few disastrous explosions have occurred when barges and ships were being loaded. Tank trucks have been known to explode during loading even though properly grounded.

While the precautions of grounding prevent a charge from accumulating on the truck body, they are of no value in protecting against sparks occurring on the free oil surface inside of a tank. Charges sufficient to create sparks on a free oil surface do not occur frequently on small surface areas such as those found in tank trucks, unless conditions are particularly conducive to a high rate of charge.

An old problem. The phenomenon of sparks on a free oil surface has been known for many years. It has been observed in air-blown batch agitators during the settling period following the water wash. The sparks dart about in an erratic pattern over the surface of the naphtha, and the old time operators referred to them as "go devils."

The mixture at the surface is usually too rich to ignite, but numerous agitator fires over the years attest to the fact that this is not always the case. Steam blanketing has been commonly used as a protection against static in batch agitators. Agitators of this type are, of course, being replaced in the industry by continuous treating processes.

You can fully appreciate the problem of mitigating the charge on a free oil surface by realizing that charge can not be removed from a dielectric by tying a ground wire to it, or any number of ground wires. It is necessary that one of the following elements be reduced to either a safe value or eliminated:

- Generation
- Volume charge
- Surface charge

Protection against the hazard of static charges on a free oil surface has received much attention. The obvious solution is to eliminate the free oil surface and this has been done by using floating roof tanks. These tanks are used only for large fixed storage and such a solution is not applicable in mobil services.

There are hopeful indications that non-contaminating conductive additives may be found that will lower the resistivity of the oil to a value where static generation would be eliminated. Thus far a number of additives have been found to eliminate static generation but were unsatisfactory because they contaminated the products. It is quite possible, however, that a suitable additive may yet be found. A number of other ideas have been suggested for solving this problem but none have looked very promising.

To effect an engineering or practical solution of the oil surface charge problem it is necessary to know among other things, something about the distribution of charge inside of a tank. This might appear at first thought to be a simple undertaking. However, the minute a probe is inserted into a tank, the electric field is distorted by the probe and readings taken from the probe do not give the true picture.

Situations like this confront investigators with some challenging problems. This is the reason that no ready solution is rapidly forthcoming.

(Originally presented before PIEA and PESA meeting, Galveston, Texas, April 1959.) # #

About the Author

John C. Howard is assistant chief engineer in charge of electrical design, General Engineering Department, Standard Oil Co. (Indiana), Whiting. He received a B.S. degree in electrical engineering from the University of Illinois in 1922. Howard then worked as a radio station operator and as a design engineer for Illinois Central Railroad (Chicago Terminal electrification), and joined Indiana Standard in 1928 as an electrical design engineer. He is active in committee work for API and AIEE.

What's Happening...

New Hydrocracking Process Announced

California Research Corp.'s process will upgrade a wide variety of petroleum fractions

A new commercial process for hydrocracking petroleum distillates at low temperature and relatively low pressure has been announced by California Research Corp., research subsidiary of Standard Oil Co. of Calif. Called Isocracking, the new process is in full-scale operation at Standard's Richmond refinery.

Economic studies show that hydrocracking with the Isocracking process will be economically attractive in a wide range of refinery situations:

	HEAVY CRACKED NAPHTHA		CATALYTIC CYCLE OIL	
TYPICAL FEED STOCKS				
Gravity, °API	36.7		31.0	
ASTM D86 or D158, °F				
5	372		415	
10	376		430	
50	383		478	
90	405		523	
EP	450		570	
Composition, LV%				
Para	25		5	
Naph	32		46	
Arom	43		49	
	100		100	
Octane Rating				
F-1 at 3 ml TEL	80.7		....	
TYPICAL PRODUCTS				
Yields	WT%	LV%	WT%	LV%
C_1	0.01	....	0.01	....
C_2	0.6	....	0.1	....
C_3	3.6	....	1.7	....
Isobutane	9.4	14.0	4.5	7.0
n-butane	4.0	5.8	2.8	4.2
C_5 + Isocrackate	84.8	94.0	93.4	105.4
C_4 + Isocrackate	98.2	113.8	100.7	116.6
GASOLINE STOCKS	C_5-180° F.	180-360° F.	C.-180° F.	180-400° F.
Yield, Vol % C_5 +	28	72	23	77
Inspections				
Gravity, °API	81.7	46.1	82.0	44.3
Octane Rating,				
F-1 at 3 ml TEL	100	94.6	100	93.8
F-2 at 3 ml TEL	100.6	....	100.6	....
F-1 at 3 ml TEL*	....	104.8	....	104.5
Composition, LV%				
Para	81	22	84	23
Naph	16	38	13	36
Arom	3	40	3	41
	100	100	100	100

* After platinum reforming to 91V% C_5 +

The new hydrocracking process is a valuable tool for balancing refinery operations in a competitive changing product situation.

- For fuel oil reduction and crude throughput reduction—in refineries where light gas oils are available in excess of fuel oil viscosity blending or distillate product sales requirements. This is particularly true of coking refineries.
- For octane improvement—payouts are particularly attractive when octane improvement must be obtained in an expanding gasoline market.
- For gasoline volatility control—Isocracking is especially valuable when volatility specifications prevent inclusion of otherwise available heavy high-octane stocks.
- When incremental cracking capacity is required.
- For maximum gasoline production.

Versatility makes the new hydrocracking process a particularly valuable tool for the refiner seeking to balance his operations in a competitive changing product situation.

The results of Isocracking are governed by reaction mechanism rather than by thermodynamic equilibrium limitations. As a consequence, unusual results are obtained:

- Light product fractions contain isoparaffins in production which are far on the iso side of thermodynamic equilibrium.
- Heavy aromatics are cracked without substantial saturation or loss of ring structure.
- Aromatics are dementhylated without producing methane.
- Heavy naphthenes are cracked without appreciable loss of ring structure and characteristically yield naphthenes in the C_7-C_8 boiling range.
- Naphtha fractions are produced which can be catalytically reformed to the 104-108 octane level in high yields and at moderate severity.

The economics for Isocracking are favorable, in view of the fact that it employs conventional-type equipment

SERVICE: aromatics to aspirin

Benzene and Toluene currently produced at Cosden Petroleum Corporation's Big Spring, Texas refinery, so greatly exceed the purity requirements of the ASTM "Nitration Grade" specifications, that these products are now being used directly in the manufacture of pharmaceuticals such as aspirin and cortisone.

As integral parts of the UOP Rexforming® and Udex® units at Big Spring, Western heat exchangers perform an important service in the conservation and transfer of heat during the selective extraction of these aromatic hydrocarbons.

Heat Transfer requirements for petrochemical processes present a worthwhile challenge, and Western will continue to expand its sphere of influence in the petroleum industry's growing importance to chemical consumers.

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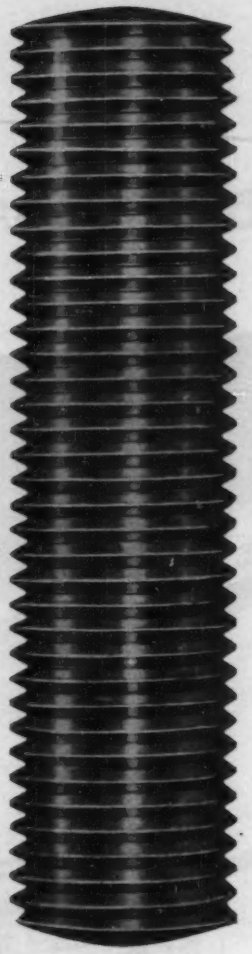

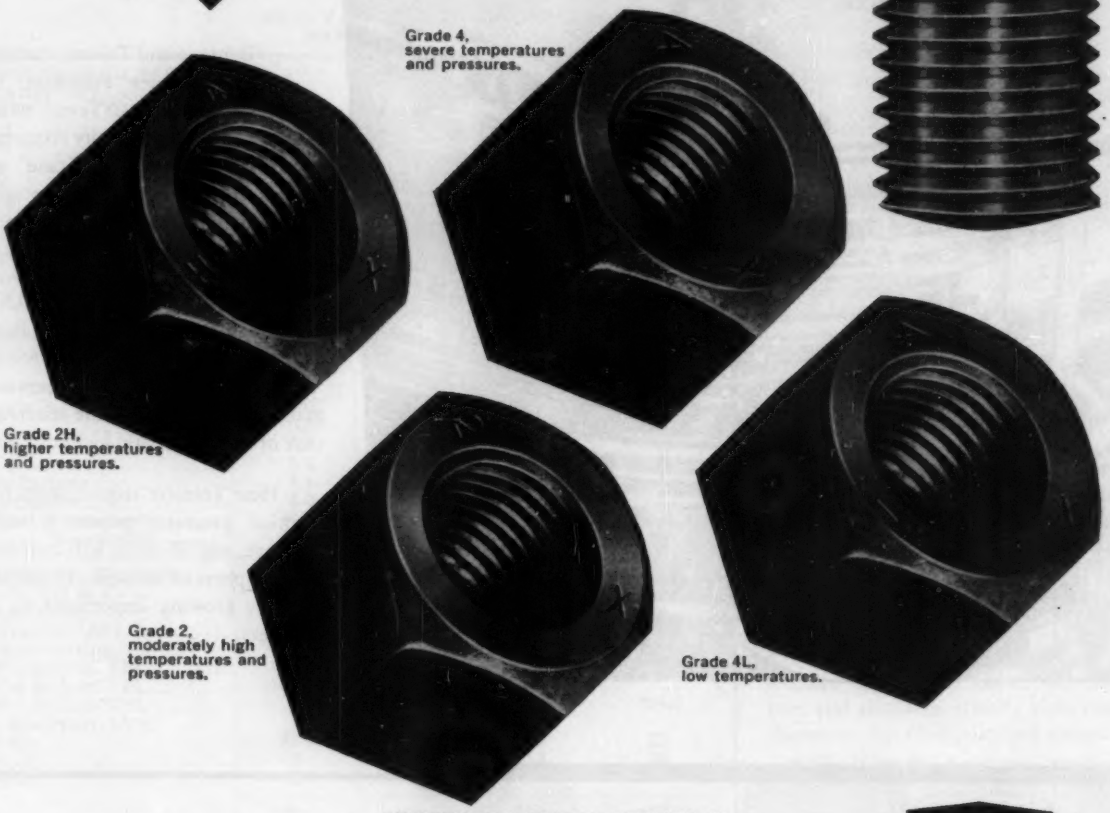

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Grade 2H, higher temperatures and pressures.

Grade 2, moderately high temperatures and pressures.

Grade 4L, low temperatures.

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and operates at moderate process conditions.

The on-plot cost of an Isocracker unit is estimated to range from $350 to $450 per daily barrel of reactor feed. The plant operates with a high per-pass conversion in the range of 50 to 70 percent. Operating costs are comparable to those for a two-stage catalytic reformer and economic studies show that installation of an Isocracking plant will often pay out before tax in under two years.

While availability of reformer hydrogen is an economic advantage, the installation of a hydrogen manufacturing plant adds only about six months to the project pay-out period.

For increasing gasoline octane level, the new process is more attractive in many situations than other available processes. Data are given in the table. Substantially the same plant can be used for fuel oil reduction purposes. In the latter case with feed available at cutter stock value, an Isocracker will usually pay out in 1.2 to 1.7 years before taxes.

Development of the new process is characterized by a few statistics: About 1,000 catalysts were prepared and tested during development work to date. More than 2,000 catalyst screening tests were performed. Close to 100,000 hours of pilot plant operation were completed before the commercial plant went on stream. Operations of the Richmond commercial plant have substantiated the pilot plant development of the process.

Technical 'United Nations' Opens in New Jersey

A 675-acre scientific center, described as a "technical United Nations," has been opened at Florham Park, N. J., by Esso Research and Engineering Co. The facilities, representing the biggest expansion in the 40-year history of the nation's largest oil research firm, were dedicated during a program in which President Eisenhower's scientific adviser, Dr. George B. Kistiakowsky, stressed the importance of basic research in international affairs.

Located on an historic estate in Northern New Jersey, the center includes three structures housing 800 engineers, scientists and aides. Initially it will be devoted to engineering and oil processing research. Headquarters activity and other research will continue at the company's 20-building facilities in Linden, N. J.

One interesting feature of the new research center is the Process Research Building with its 11,000-square-foot bay area. Here, new processes and improved versions of old processes are "scaled up" into pilot plant units.

The largest structure is an office building for engineering personnel. Three

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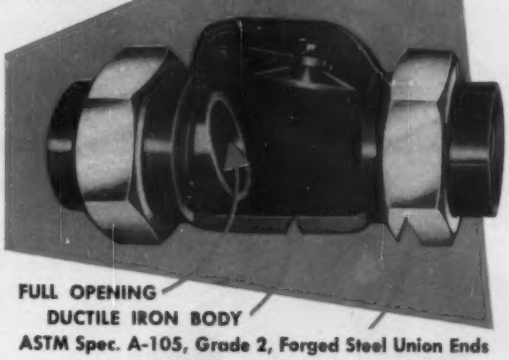

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ASTM Spec. A-105, Grade 2, Forged Steel Union Ends

Here is one valve designed to take the rough handling necessary in most applications!

Metallographic structure of the ductile iron body resists leakage or seepage of liquids or gases.

In production, pipeline or refinery use—the "502" has earned a reputation for long-life service and satisfaction . . . and now it's a better valve, a better buy than ever!

Catawissa "502" Check Valves withstand severe service conditions with built-in resistance to wear, shock or elevated temperatures. Their resistance to oxidation and a wide variety of corrosive media make them especially valuable where corrosion is a factor. Get the full story on all of their extra-value features!

There's no need to "beat a path to our door" . . . just write for Catalog 58 or call your favorite supply store!

1917 42 1959
YEARS OF DEPENDABILITY

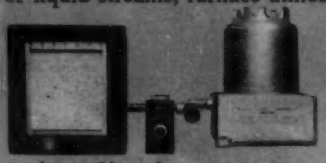
CATAWISSA VALVE & FITTINGS CO.
CATAWISSA • PENNSYLVANIA

For more data on advertised products, use Readers' Service Cards, last page.

TORTURED WITH WATER PROBLEMS?

CEC Moisture Monitors detect 1 part per million

Our complete line of Moisture Monitors accurately measure water in gas or liquid streams, furnace atmospheres, dry-gas containers. Available in laboratory, high-pressure, and process versions, these instruments can precisely determine water concentrations of less than one part per million for either gas or liquid applications. They can also be used to actuate automatic process controllers. For more information, call your local CEC Sales & Service Office, or write for the new Moisture Measurement folder CEC 1851-X6 containing brochures on all CEC Moisture Monitors.



Analytical & Control Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS / 360 sierra madre villa, pasadena, california

Happenings . . .

stories high with 640-foot frontage, it contains the computing center, medical facilities, a library and a 500-person cafeteria. The third building is for mechanical and other services.

Mechanical Division Is Formed By Esso R & E

Esso Research and Engineering Co. has created a new 300-man division at Linden, N. J., drawing its strength from existing personnel. To be known as the Mechanical Division, the new unit consolidates efforts now conducted by four separate divisions.

The new division will operate on a company-wide basis and provide the development, design, engineering and building of specialized equipment and tools for conducting research.

Imports for 1959 Ahead of Comparable 1958 Period

Increased volume of residual fuel oil imports in the first three months of this year (just before mandatory controls) has moved total imports in the first three quarters of 1959 a little ahead of a comparable period in 1958, according to the Bureau of Mines. Imports in the first nine months of 1959 have averaged 1,790,400 bpd compared with 1,608,000 bpd in the same period for 1958. Residual fuel oil imports were at a rate of 584,000 bpd the first quarter of 1958, but jumped to a rate of 918,000 bpd in a comparable period for 1959.

USSR Increases Crude Oil Exports Over 1958 Level

The U.S.S.R.'s exports of crude oil and products are each expected to exceed 200,000 bpd this year, according to the Statistical Bureau in Moscow. The crude increase to 200,000 bpd came up from 118,000 bpd in 1957 and from 182,000 bpd in 1958. Beginning with a base of 156,000 bpd in 1957, product exports reached nearly 180,000 bpd in 1958. Crude, diesel fuel and gasoline production reportedly either met or exceeded plan targets.

Part-Throttle Knock Can Be Controlled, Says SAE

Ways of controlling part-throttle knock, which has been a problem in some late model automobiles, were outlined at a recent meeting of SAE by Ethyl Corp. The problem can be reduced by modifying engine design or fuel properties, the most effective engine change being to reduce vacuum spark advance in the critical knocking range, which is about 8 to 14 inches of manifold vacuum. However, this may lower fuel mileage during part-throttle operation. For cars operating in

WOLVERINE TRUFIN®

SAVES YOU MONEY

8 WAYS

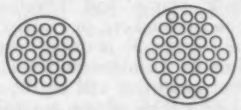
Anytime you cut down costs, you pep up the profit picture. Here's an idea: where heat exchange costs are concerned, Wolverine Trufin Type S/T—the integral finned condenser tube—can help you save money *eight* ways. Take a look at the points listed below. They can open the door to substantial savings, provide added dividends in increased efficiency.

✓ **Because Trufin is an extended surface tube—with fins extruded right from the tube wall—it has more than twice the heat transfer surface of plain tube. Less tube is required because Trufin transfers more BTU's per foot of tube.**

✓ **Fewer tubes mean smaller shells, headers, baffles, etc. This saves material requirements.**

✓ **Fewer tubes mean fewer holes to drill—less rolling-in operations. Direct result: substantial savings in labor costs.**

✓ **To transfer a given heat load—when Trufin is used—much less weight of over-all tube metal is required. This is a real saving when expensive alloys are necessary. This is of greatest importance when alloys are in short supply, as a given quantity of metal in Trufin transfers much greater heat loads.**



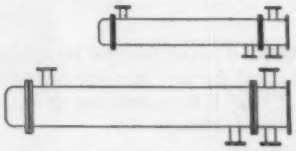
FEWER TUBES MEANS SMALLER SHELLS

✓ **Because of these material savings, lighter units—requiring less structural support—can be designed. This is vital when exchangers are to be mounted on superstructures.**

✓ **Maintenance costs are low. Costs of replacement tubes are reduced; fewer tubes result in less cleaning time, more "on stream" time. Actual operating data proves that Trufin withstands fouling for longer periods than does prime surface tube. This increases the length of operating time between change-overs.**

EQUIVALENT TUBES WITH THE SAME SURFACE

✓ **Smaller, lighter units result in easier handling and lower shipping costs.**



TRUFIN MEANS SMALLER UNITS

✓ **Where space is at a premium—as in revamped units—Trufin units are smaller.**

***There they are*—eight job-proven ways in which Wolverine Trufin Type S/T condenser tube can save you money. Write for a copy of Wolverine's new Trufin Catalog today!**

CALUMET & HECLA, INC.
CALUMET DIVISION
URANIUM DIVISION
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In Canada:
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WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17236 Southfield Road
Allen Park, Michigan
Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

See Wolverine Tube at Booth 1111—27th Exposition of the Chemical Industries—November 30 through December 4, New York City.

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario.

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

REWARD

Startling claim . . . but it's true! You'll find the revolutionary Hartzell Controllable Pitch Fan will reward you with continuous operating efficiency and economy in many ways and for many years to come. Here's how!

COOLING MAGIC is accomplished by variable blade pitch settings that are instant and automatic. The fan holds outlet temperature fluctuation to ±1½° F by increasing or decreasing blade pitch as the cooling requirements change.

UP TO 50% POWER SAVING. Because the pitch of the fan blades is rarely at a maximum, considerable savings in power consumption is made. In fact, a Hartzell Controllable Pitch Fan may save more than enough in power to pay for itself.

COMPLETE SIZE RANGE from 7 to 12-foot diameters in four and six blade assemblies are made from Hartzite plastic, a Hartzell exclusive, and aluminum—available in 7 to 10-foot diameters.

So if you want to be REWARDED with efficiency and economy for years to come, call on your Hartzell field engineer, or write for bulletin A-111B on Hartzell Controllable Pitch Fans for heat exchangers. You'll be glad you did.

HARTZELL **HARTZELL**

A Division of Castle Hills Corp. **PROPELLER FAN CO. Piqua, Ohio**

PROPELLER TYPE FANS AND BLOWERS • ROOF VENTILATORS • UNIT HEATERS • ENGINEERING OFFICES IN PRINCIPAL CITIES

Happenings . . .

city traffic, a considerable part of the total fuel consumption occurs in the part-throttle load range.

The most important fuel factor affecting part-throttle knock is the motor octane number of the gasoline, Ethyl reports. Increases in motor method octane ratings give equal improvement in part-throttle road ratings at low engine speeds. At high speeds, road ratings are boosted about two octane numbers for each one-unit increase in motor ratings.

Exec Urges Effort To Keep Scientists From Unions

"Organized labor's efforts to 'reach future scientists on the campus before professional societies can get to them' is presenting a serious challenge to the latter," warned E. A. Hartsook of Standard Oil Co. of Calif. at a recent AIME meeting. He added that throughout the country a growing effort is being expended not only to contact young people in their formative years, but also to attempt organization of scientific and engineering personnel in industry. Hartsook added that there is "virtually no unified effort to counteract the political challenge of unionism."

U.S. Crude Oil, Product Imports Rise for August

Imports of crude oil and products into the continental United States rose slightly in August to 1,397,000 bpd, compared with a July average of 1,309,000 bpd and an August 1958 average of 1,542,000 bpd. Crude imports averaged 902,000 bpd in August compared with 830,000 bpd in July, and 952,000 bpd in August 1958. Residual imports averaged 385,000 bpd in August, 366,000 bpd in July, and 404,000 bpd in August 1958.

Gathering of Statistics On Residual Stocks to Start

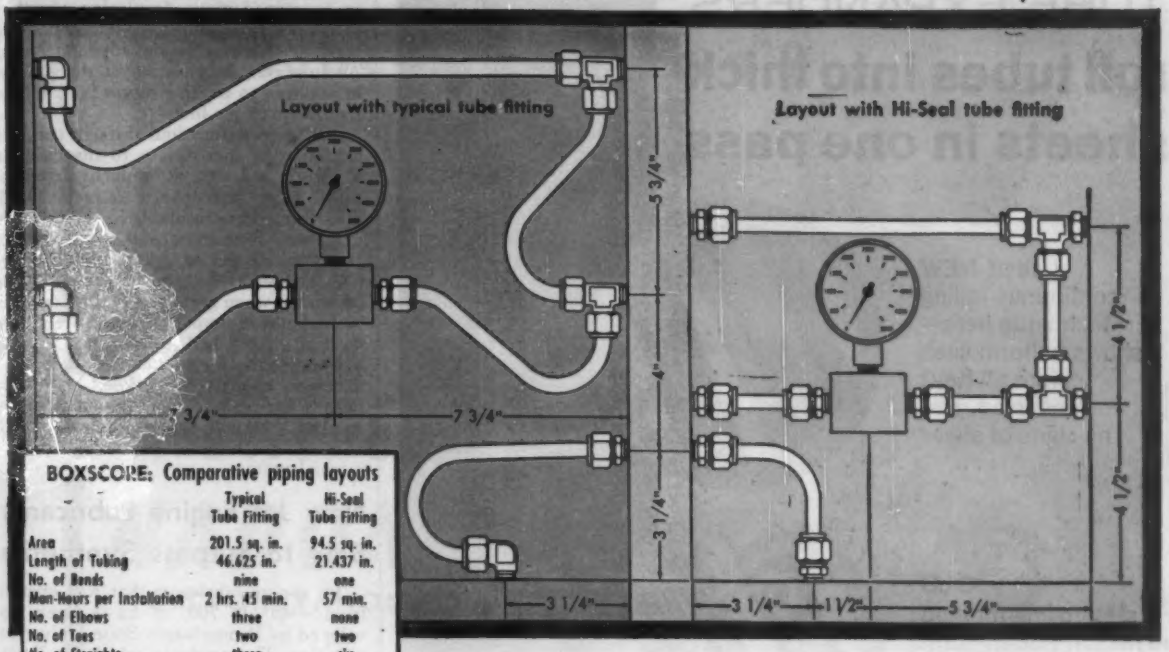
A gathering of monthly statistics on stocks of residual fuel oil at refineries, bulk plants and terminals (including bonded bunkers, in District 1 and in part of District 3) is to be started by the Oil Import Administration. The 36 residual fuel importers will be required to report their stocks of non-bonded and bonded residual fuel oil on a mandatory basis. Voluntary information will be asked of 100 non-importers. Companies are also being asked to report historical stock levels for 1957-59.

New Petroleum Refining Process Developed by UOP

A new petroleum refining process, Merox, has been developed by Universal Oil Products Co. The process is described as an inexpensive way to remove harmful sulfur compounds from a wide

IMPERIAL *Engineering and Data File*

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS



BOXSCORE: Comparative piping layouts

	Typical Tube Fitting	Hi-Seal Tube Fitting
Area	201.5 sq. in.	94.5 sq. in.
Length of Tubing	46.625 in.	21.437 in.
No. of Bends	nine	one
Man-Hours per Installation	2 hrs. 45 min.	57 min.
No. of Elbows	three	none
No. of Tees	two	two
No. of Straights	three	six

How Hi-Seal saves space—cuts costs

. . . makes possible reductions up to 50% in required piping area . . . up to 66⅔% in installation time!

Imperial Hi-Seal tube fittings open up economical *new piping design concepts* for instrumentation, hydraulic circuits, and other tubing installations. Hi-Seal makes possible far more compact layouts than can be made with conventional fittings — in addition, it brings *new ease and speed* to joint making and utmost reliability.

These design considerations are illustrated in the tubing layouts above. The diagrams show how Hi-Seal actually eliminated nine tube bends . . . saved more than one-half on tubing needed. Total layout area required by Hi-Seal is only 94.5 sq. in., compared to 201.5 sq. in., when an ordinary fitting is used. And 189% *more* manhours were required to tube up the circuit with a typical fitting.

Several key fitting design factors account for Hi-Seal piping economies: (1) Hi-Seal makes a positive butt joint — no need to spring tubing; (2) speedy, foolproof assembly — it is impossible for the fitting to be assembled with the alloy steel sleeve in reverse position; (3) there is no danger of over-torqueing . . . when threads on body of fitting are covered, a pressure-tight seal has been made, a visual assurance of a correct joint; (4) under tests, Hi-Seal fittings have withstood pressure of 4,000 psi at conditions of −320° F. to over 700° F.

with *no* leakage; (5) Hi-Seal fittings can be disconnected and reconnected as often as desired.

Complete line — Hi-Seal fittings are available in brass, steel, stainless steel. Also furnished in Titanium, Tantalum and other metals. Steel fitting supplied with cadmium plate or black phosphate finish. Conform to J.I.C., A.S.M.E. and A.S.A. standards. In sizes for ⅛" to 1½" O.D. tubing. Furnished with Long Dryseal pipe threads or straight thread port seal.

Write for Bulletin No. 3061

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Ill.

In Canada: 18 Hook Ave., Toronto, Ont.

New high-pressure valves assemble directly to tubing — eliminate additional fittings

A revolutionary new line of Imperial needle valves designed for working pressures up to 5,000 psi., and temperatures to 450° F., employs Hi-Seal tubing connections.

Write for Bulletin 3096, or Catalog No. 200

CONTACT YOUR INDUSTRIAL DISTRIBUTOR OR WRITE TO:

THE IMPERIAL BRASS MFG. CO.
Dept. PR-119, 6300 W. Howard St.,
Chicago 48, Ill.
Please rush me Bulletins
☐ No. 3061 ☐ No. 3096 ☐ Cat. No. 200

Name .....
Title .....
Company .....
Street .....
City ..... Zone ..... State .....

For more data on advertised products, use Readers' Service Cards, last page.

NEW ELLIOTT TUBE EXPANDERS roll tubes into thick sheets in one pass

Use of **NEW** continuous-rolling technique here—shows uniform seal, with all Keys preserved, and no signs of shear

OLD step-rolling method results in non-uniform surface . . . distortion of Keys where rolls have overlapped

Better seal... Smoother surface... Much Faster operation

This new concept in tube expanders was developed by Elliott to roll the thickest tube sheets. Using a continuous-rolling method, it eliminates many problems common to step-rolling, may be operated protractively or retractively, saves time, assures uniform, smooth surfaces, avoids annular voids or erratic tube inside diameters, provides better seal.

Accessories

Elliott also makes a complete line of retubing accessories, including both electric and air magnetic Tube Rolling Controls, Tube Gages, Tube Plugs, Tube Cutters, etc.—in addition to a complete line of tube expanders. *Ask for Bulletin Y-52.*

ELLIOTT Company
LAGONDA PLANT, SPRINGFIELD, OHIO
Y9-5

Happenings . . .

range of gasoline and light distillate oils. A catalyst of undisclosed type is used.

The process can be used for either mercaptan extraction alone (replacing conventional regenerative caustic washing), or sweetened alone (replacing plumbite or copper sweetening), or it can perform both functions in a combined operation. An important application of the process, in addition to treating motor fuel, will be treatment of jet fuels.

The process functions through catalytic oxidation of mercaptans to disulfides in a caustic solution at ambient temperatures, using atmospheric oxygen. Disulfides formed are insoluble in the solution.

In both sweetening and extraction applications of the Merox process, a catalyst is used either in solution in the caustic or, when greater activity is needed, the catalyst is supported on a carrier and used in a fixed bed.

Catalyst life for commercial units using dissolved catalyst has exceeded "20,000 barrels per pound." Based on that figure, catalyst cost will be less than one-tenth of a cent per barrel of oil treated in commercial units.

New Jet Engine Lubricants Said to Surpass Synthetics

Jet engine lubricants that will operate from —65° to 700° F have been developed by Pennsylvania State University scientists. The products, which use Pennsylvania grade crude oil as a base, are said to be superior to synthetic lubes currently in use because they are more stable at higher temperatures, yet have lube characteristics that are as good or better at lower temperatures. The Pennsylvania Grade Crude Oil Association sponsored the study at the Air Force's request.

New Gasoline Additive Developed By Ethyl Corp.

A new gasoline additive consisting of a mixture of TEL and methylcyclopentadienyl manganese tricarbonyl is being produced by Ethyl Corp. The company says the additive will "substantially increase the economic usefulness of tetraethyl lead to refiners and the motoring public." The company added that the mixture is the most effective antiknock compound to be marketed in more than 35 years.

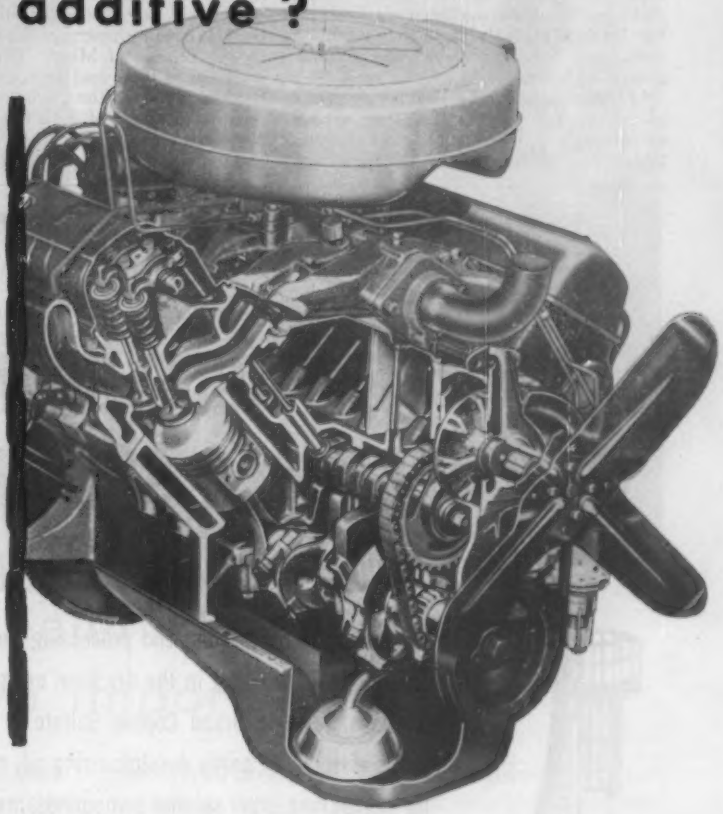
Labor Must Recognize Need For Flexibility, Says Exec

Labor's refusal to recognize management's responsibility to manage flexibly for improved efficiency has been the central cause of current labor disruptions in industry, charges John E. Swearington, president of Standard Oil Co. (Indiana). He added that "if management surrenders this responsibility, labor will lose its right to work.

"Industry's very survival is at stake,

considering CYCLOHEXANONE as a lube-oil additive*?

get a test-sample of National NADONE®
(CYCLOHEXANONE)



"The highest quality you can get . . . in any quantity you can use"—that's the simple twelve-word story of National NADONE (Cyclohexanone). It has every desired attribute for lube-oil use.

Made in a modern new plant by our direct process from basic Allied Chemical raw materials, NADONE has exceptional solvent power and exceptional purity, too. (99.7% minimum)

We'll gladly send a generous test-sample quantity for your lab work and our 32-page Technical Bulletin I-19 containing complete properties and a wealth of other valuable data.

* as described in U.S. Patent 2,389,608.

NATIONAL ANILINE DIVISION
40 RECTOR STREET, NEW YORK 6, N. Y.
Atlanta Boston Charlotte Chicago Greensboro Los Angeles
Philadelphia Portland, Ore. Providence San Francisco
In Canada: ALLIED CHEMICAL CANADA, LTD., 100 North Queen St., Toronto 18
Distributors throughout the world. For information:
ALLIED CHEMICAL INTERNATIONAL • 40 Rector St., New York 6, N. Y.

Allied Chemical

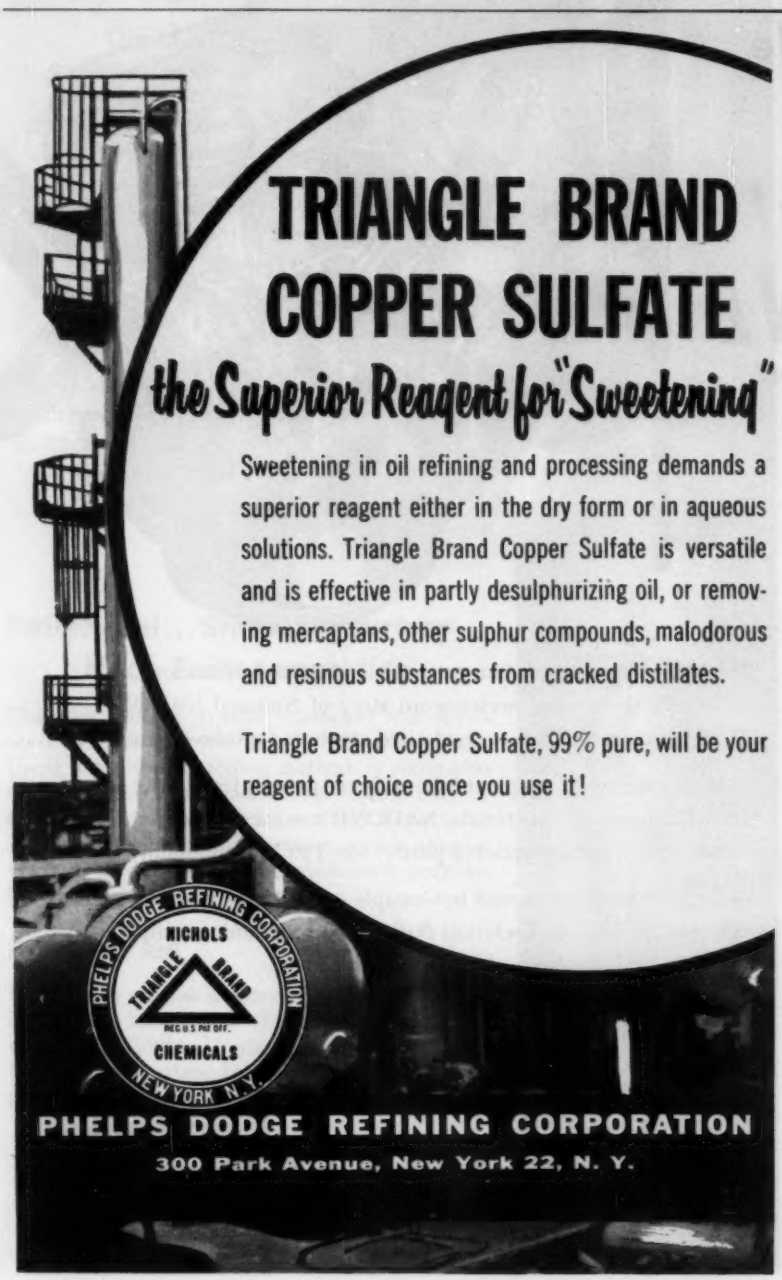
For more data on advertised products, use Readers' Service Cards, last page.

for it has been amply proved by now that business can carry corporate fat only at the risk of a corporate coronary," Swearington said. "In the prosperous post World War II period, when money came relatively easy, management went along with many inefficient practices . . . But now the impact of relentlessly rising costs is full upon management . . . It has become urgently clear that we must make the fullest possible use of improved technology.

"Management must recognize problems of individual employes . . . After a year of paternalism, it cannot discard all considerations of security in the name of hard-nosed, impersonal efficiency . . . There must be more jobs at higher wages. But the jobs must be economically justifiable ones, not mere time-killing exercises in made-work."

U.S. Crude Export and Consumption Up This Month

Domestic crude oil to be consumed in the United States or exported in November has been estimated at 6.9 million bpd by the Bureau of Mines. This compares with 6.8 million bpd forecast for October. Included in the estimate is a total gasoline demand of 4.02 million bpd in November, gasoline yield of 45 percent, and crude runs of 7.8 million bpd.


TRIANGLE BRAND
COPPER SULFATE
the Superior Reagent for "Sweetening"
Sweetening in oil refining and processing demands a superior reagent either in the dry form or in aqueous solutions. Triangle Brand Copper Sulfate is versatile and is effective in partly desulphurizing oil, or removing mercaptans, other sulphur compounds, malodorous and resinous substances from cracked distillates.
Triangle Brand Copper Sulfate, 99% pure, will be your reagent of choice once you use it!
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300 Park Avenue, New York 22, N. Y.

Refiners Urged To Reduce Excess Petroleum Stocks

"Refiners should help reduce the nation's excess petroleum stocks" according to Harry C. Jones, president of the Texas Independent Producers & Royalty Owners Association. In a letter to management of 30 integrated oil companies, he said "it has become a standing joke at statewide hearings of the Railroad Commission that there seems to be no communication between the refining and producing branches of some companies.

"A directive from the top management calling for even the slightest adjustment percentagewise in the rate of production, refining and marketing could restore stability and avert injury to the whole industry. We are convinced that a remarkable degree of unity within our industry could be assured if top management of the leading integrated companies should see fit to make these minor 'moveover' gestures, with lasting benefits to themselves as well as their independent producer competitors."

NGAA Panhandle Meet To Be Held November 20

Modern control systems, water treating and preventive maintenance techniques for gas processing operations will be principal topics of technical papers at the NGAA Panhandle Plains Regional Meeting, to be held November 20 at the Herring Hotel, Amarillo. Practical application and operation of latest electronic equipment, along with advanced operating methods, will receive particular emphasis.

Topics will include: Your Place in Politics, Operation of Electronic Instrumentation in Gasoline Plants, Gas Engine-Compressor Performance as Seen With an Electronic Analyser, How Texaco's Amarillo Refinery Solved its Water Problem, Cooling Tower Wood Deterioration, Lube Oil Analysis as a Practical Tool in Preventive Maintenance, and Computer Control of Internal Reflux in Fractionation Columns.

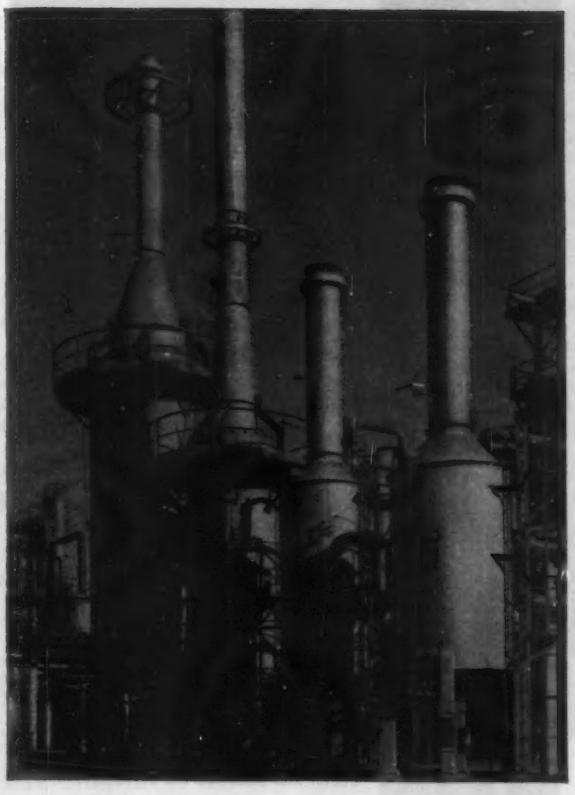
October Octane Ratings Unchanged From September

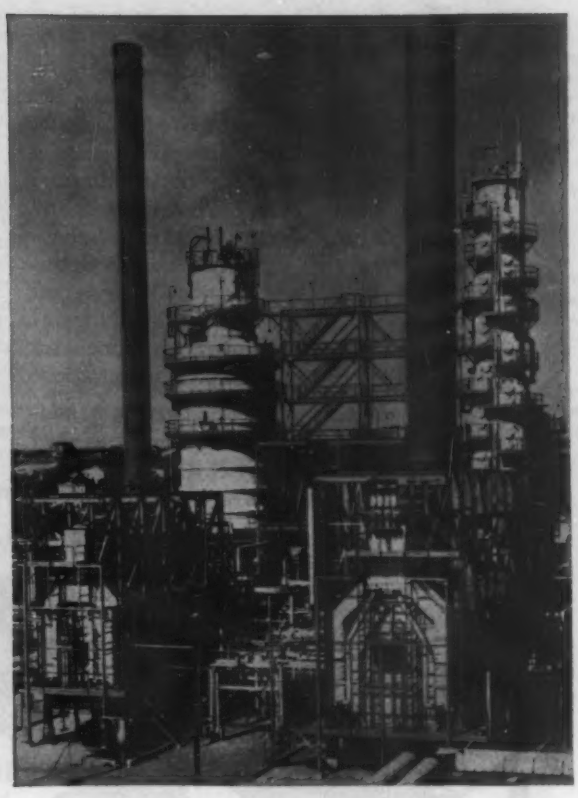
Gasoline on sale at service stations in October showed national weighted averages of 99.2 octane number for premium and 92.2 octane number for regular according to the latest monthly survey of antiknock quality compiled by Ethyl Corp.

The premium average was unchanged from September but was 0.5 octane number above a year ago. The regular average was 0.1 octane number higher than in September and 0.8 octane number above a year ago.

Twenty-three of the 57 cities in Ethyl's survey reported increases over September in the average octane number of their premium gasoline. Eighteen cities reported decreases while 16 cities were unchanged. In regular gasoline, 31 cities

For more data on advertised products, use Readers' Service Cards, last page.





Foster Wheeler Heaters . . . Different two important ways

Is there really a difference between direct-fired heaters today? The answer is in the story behind the product.

FW built the first modern direct-fired radiant heater some 40 years ago. As refineries and process plants became larger and more complex, FW engineers designed and developed improved heaters for them. The products of this pioneering make up the large selection of modern vertical and horizontal heater designs offered by FW to the process industry today.

And while this wealth of experience is an important difference, there is more than experience alone in the service "package" that goes with FW direct-fired heaters.

This second difference is specialized Heat Engineering . . . FW's way of integrating the heater into the overall process scheme. FW engineers give their heaters the flexibility to meet exacting process requirements. They have demonstrated that whether a single heater is rated at 500,000 or 340,000,000 Btu/hr capacity, there is no need to restrict the ultimate selection with a static product or fixed design. Each FW heater is individually tailored to "your" process.

The result is an efficient, dependable heater . . . a significant contribution to a smooth running and profitable process installation.

To get in touch with FW engineers who can survey your process heating requirements, write to Foster Wheeler Corporation, Department A, 666 Fifth Avenue, New York 19, New York.

Heat Engineered products, plants and processes . . . for the world's industrial progress

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

—petroleum processing —chemical processing —specialized installations

For more data on advertised products, use Readers' Service Cards, last page.

There is a specific A. P. Green Castable for every refractory application in the Petroleum Field. Methods of installation, including troweling, pouring, and "gun" application vary with the particular characteristics of the job. Each A. P. Green castable refractory is specifically designed to provide the required properties of insulation, strength, abrasion resistance and refractoriness for high efficiency operation.

For detailed information and recommendations write the Engineering Department of the A. P. Green Fire Brick Company . . . or call your local A. P. Green distributor.

KAST-SET
A. P. Green KAST-SET is a rapid setting, high strength refractory castable. Mixed with water, it takes on a hydraulic bond without the application of heat. KAST-SET will not shrink, has excellent resistance to abrasion, and is ideally suited for monolithic linings. It may be used at temperatures up to 2700°F.

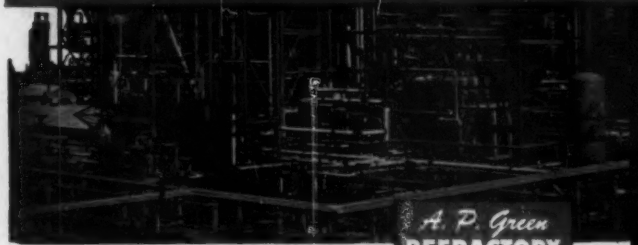
KAST-O-LITE
A lightweight, insulating castable refractory recommended for temperatures up to 2500°F. It is used for complete monolithic linings in all types of oil stills and heaters, tar stills, air heaters, heat treating furnaces, flues and stacks, and for furnace hearth insulation.

CASTABLE INSULATION NO. 20
A hydraulic-setting castable for temperatures up to 2000°F. Recommended for complete monolithic linings and lightweight panel construction in oil stills and heaters.

CASTABLE BLOCK MIX
A hydraulic-setting castable insulation for temperatures up to 1600°F. CASTABLE BLOCK MIX combines the advantages of a castable material with low conductivity and light weight.

A.P. GREEN

HIGH QUALITY REFRACTORY AND INSULATING CASTABLES ASSURE HIGH EFFICIENCY OPERATION OF PETROLEUM EQUIPMENT



ESSO Esso Standard Oil Company's fluid catalytic cracking units at the Baton Rouge Refinery where A. P. Green products are in use.

A. P. Green REFRACTORY PRODUCTS

CASTABLES FOR GUN APPLICATION

SK-7 and KS-4
were designed for use in combination to form composite linings in catalytic regenerators, reactors, and other petroleum equipment. Frequently a lining utilizing only SK-7 or KS-4 will fulfill the requirements of the job.

SK-7
Gun application of SK-7 produces a lightweight lining with excellent strength and insulating efficiency. Ideal lining for ducts, flues and breechings.

KS-4
This strong abrasion resistant castable can be gun applied with a minimum of rebound loss. Recommended for catalytic regenerator linings, stack linings, bubble towers, and duct linings exposed to abrasion or corrosion.

A. P. GREEN FIRE BRICK COMPANY
Mexico, Missouri, U. S. A.

PLANTS:
Mexico, Mo.—Woodbridge, N. J.—Sulphur Springs, Texas, Jackson, Oak Hill, South Webster, Ohio • Philadelphia, Climax, Pa. • Troy, Idaho • Pueblo, Colo. • Macon, Ga.

IN CANADA:
A. P. Green Fire Brick Company, Ltd.—Toronto 15, Ontario

DISTRIBUTORS IN THE PRINCIPAL CITIES OF THE WORLD

Happenings . . .

reported increases over September in their average anti-knock quality, four by 0.5 octane number or more. Eighteen cities reported decreases while eight cities were unchanged.

Compared with the nationwide premium average of 9.2 octane number, 17 cities reported premium averages of 99.5 octane number or higher. In regular gasoline, 20 cities showed average octane ratings of 92.5 octane number or higher, compared with the national weighted average of 92.2 octane number.

For companies marketing more than one grade of premium gasoline, the survey showed a range of 100.3 to 102.6 octane number for the highest grade, on the basis of 48 samples in 27 cities.

AIChE Meeting Slated for December 6-9, San Francisco

AIChE will hold its annual meeting in San Francisco December 6-9. It will include the following technical sessions:

- **Dec. 6,** 2:00 p.m.-4:30 p.m., Panel Discussion on Creativity.
- **Dec. 7,** 2:00 p.m.-5.00 p.m., Thermal Recovery of Petroleum (In Situ Combustion), Turbulent Mixing, Selected Papers.
- **Dec. 8,** 9:00 a.m.-11:00 a.m., Fundable Concepts of Miscible Fluid Displacement (I), Process Dynamics (I), Selected Papers.
- **Dec. 8,** 2:00 p.m.-5:00 p.m., Fundamental Concepts of Miscible Fluid Displacement (II), Process Dynamics, Outlook for Natural Resources, Selected Papers.
- **Dec. 9,** 9:00 a.m.-12:00 p.m., Quality Criteria for Catalytic Cracking Stocks and Method of Preparation (I), Operations Research, Heat Transfer, Selected Papers.
- **Dec. 9,** 2:00 p.m.-5:00 p.m., Quality Criteria for Catalytic Cracking Stocks and Methods of Preparation (II), Solvent Extraction, The Automatic Computer as a Research Tool, Selected Papers.

Houdry Offers New Process For Aromatic Light Oils

A new dual-purpose one-step catalytic process for purification and dealkylation of aromatic light oils has been developed by Houdry Process Corp., in cooperation with a steel company.

Available for general licensing to coke oven operators and petroleum and chemical companies, Houdry's new Litol process is used for processing of aromatic light oils to obtain benzene, toluene, and xylene which meet the most stringent purification specifications required by users of aromatic products. The purified benzene obtained from the Litol process typically contains less than one part per million of thiophene and has a freezing point of 5.4 degrees Centigrade or higher.

Since catalytic dealkylation is also an integral part of this process, substantial additional quantities of benzene are realized from toluene and xylene contained in the aromatic light oil feed. Destruction of aromatics in this process is negligible, resulting in extremely high yield.

The one-step catalytic process eliminates the need for a second step involving either costly azeotropic distillation or solvent extraction. This process can be utilized for dealkylation of toluene, xylene or higher aromatics from sources other than coke oven light oils to produce high quality benzene or other more valuable aromatic products.

It pays to keep up with the latest equipment developments. See page 442.

- Changing Times -

Tidewater Oil Co.'s **record-making fluid coking unit at Avon, Calif., shuts down for repair after 578 days of continuous service,** in which it processed 16.8 million barrels of feed stock without interruption.

Suntide Refining Co. and Sunray Mid-Continent Oil Co. merge with filing of certificate of ownership and merger in Delaware late in October.

New company, **Amoco Fina S.A., formed by Amoco Chemicals Corp. and Petrofina S.A., Brussels, Belgium.** Firm will manufacture and market petroleum product additives.

United Carbon Co. sells its minority interest in Odessa Butadiene and Odessa Styrene companies to El Paso Natural

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Gas Products Co., operator and majority holder in both firms.

Contract signed by which **assets of Leonard Refineries, Inc., are to be acquired by The Standard Oil Co. (Ohio).** Final approval of move will depend on stockholders' votes early in December.

Chemetron Corp.'s **Girdler Construction Division to merge with Chemical & Industrial Corp.,** Cincinnati. Girdler will be C & I's subsidiary.

Consumers will feel impact of additional $150 million that truckers will pay in gasoline taxes next year, predicts F. B. Hufnagel, Sun Oil Co. marketing vice president. Higher transportation costs to result from one-cent gallon increase.

Petroleum Chemicals, Inc., leases cavern one-half mile below earth's surface at Sulphur, La., to store ethylene. Owner of cavern—Runnels Gas Products Corp., Houston.

Universal Oil Products Co.'s Pilot Plant Division and service lab employes **complete a million man hours without lost-time accident.** Record started in December 1956.

Magnolia Petroleum Co. changes name of 38-year-old, 29-story Dallas office building from "Magnolia" to Mobil Building, to coincide with Magnolia's becoming part of Mobil Oil Co.

Mid-Valley Utility Constructors, Inc., Houston, changes name to Mid-Valley, Inc. Firm is currently performing construction projects in 10 states.

Derby Refining Co. purchases Ames Oil Co., Western Kansas jobber and operator of several bulk plants. Price was not disclosed.

French and German Consumers feel American gasoline is best available, says Opinion Research Corp. Research project involved interviews with 735 French and German nationals.

W. R. Grace & Co. and Gonzalez Chemical Industries, Inc., Puerto Rico, sign operating contract under which Grace will manage and run Gonzalez ammonia and ammonium sulfate plant, Guanica, Puerto Rico.

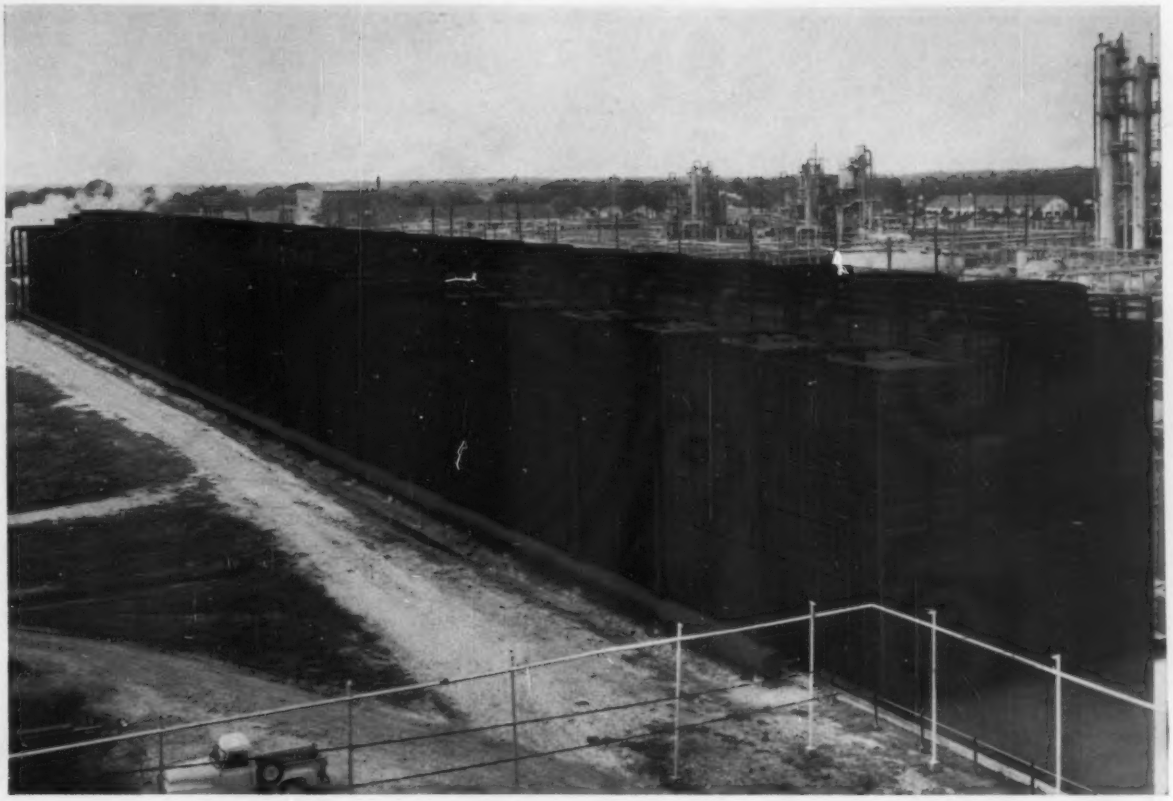
The Dow Chemical Co. forms Saginaw Bay Division, grouping three separate Dow operations in Bay City, Mich., on a 1,400-acre tract on the Saginaw River. **Included are newly-completed plants moving into operation.**

Ashland Oil & Refining Co. acquires Louisville Refining Co., Louisville, Ky., and subsidiary, producers Pipeline Co., from Farm Bureau Cooperative Association, Columbus, Ohio. **Deal involves 8,000-bpd refinery and 250-mile pipeline.**

Standards for antismog automobile device established by Los Angeles County Board of Supervisors include: Cost of less than $100, 80 percent efficiency in removing polluting emissions, life expectancy of at least 25,000 miles.

Meetings Calendar

Nov.	
20	**Natural Gasoline Association of America,** Panhandle-Plains Regional Meeting, Herring Hotel, Amarillo.
29-Dec4	**American Society of Mechanical Engineers,** Annual Meeting, Chalfonte Haddon Hall, Atlantic City.
30-Dec4	**Exposition of Chemical Industries,** New York Coliseum.
Dec.	
1- 2	**Western Petroleum Refiners Association,** Oil Industry Computer Conference, Hotel Tulsa, Tulsa.
3- 5	**American Chemical Society,** Southwest Regional Meeting, Baton Rouge.
6- 9	**American Institute of Chemical Engineers,** West Coast Meeting, Sheraton Palace Hotel, San Francisco.
11–15	**Society of Automotive Engineers,** Meeting, Sheraton-Cadillac and Statler Hotels, Detroit.
13–16	**Material Handling Institute,** Annual Meeting, Savoy-Hilton Hotel, New York.
Jan. 1960	
22	**NGAA,** Gulf Coast Regional Meeting, Robert Driscoll Hotel, Corpus Christi
25–28	**Plant Maintenance & Engineering Show,** Convention Hall Philadelphia.
31-Feb5	**American Society for Testing Materials,** Committee D-2 Meeting, Statler Hotel, Detroit.
Feb.	
1–5	**ASTM,** Committee Week, Hotel Sherman, Chicago.
21–24	**AIChE** Meeting. Hotel Biltmore, Atlanta.
23–26	**ASME,** Symposium on Thermal Properties of Gases, Liquids and Solids, Purdue University.
26	**NGAA,** Permian Basin Regional Meeting, Lincoln Hotel, Odessa, Texas.
March	
6- 9	**ASME,** Gas Turbine Conference and Exposition, Rice Hotel, Houston.
14–18	**National Association of Corrosion Engineers,** Annual Meeting, Memorial Auditorium, Dallas.
18	**NGAA,** Oklahoma Regional Meeting, Biltmore Hotel, Oklahoma City.
April	
19–21	**Southwestern Gas Measurement Short Course,** Drill Hall, North Campus, University of Oklahoma.
20–22	**National Petroleum Association,** Semiannual Meeting, Hotel Cleveland Cleveland.
20–22	**Texas A. & M. Symposium,** Instrumentation for the Process, College Station, Texas.
25–29	**American Welding Society,** Annual Meeting and Welding Exposition, Los Angeles.
27–29	**NGAA,** Annual Convention, Rice Hotel, Houston.
May	
2- 6	**American Petroleum Institute,** Midyear Meeting, Safety and Fire Protection Committees, Atlanta-Biltmore Hotel, Atlanta.
9–12	**API** Midyear Meeting, Division of Refining, Statler and Sheraton-Cadillac Hotels, Detroit.
9–13	**American Society for Metals,** Southwestern Metal Congress and Exposition, Sheraton and Other Hotels, Dallas.
23–26	**Design Engineering Show,** New York Coliseum.
June	
5–10	**SAE,** Summer Meetings, Edgewater Beach Hotel, Chicago.
19–22	**AIChE,** Meeting, Del Prado Hotel, Mexico City.
26-Jul 1	**ASTM,** Annual Meeting and Apparatus Exhibit, Chalfonte-Haddon Hall, Atlantic City.
Sept.	
25–28	**AIChE** Meeting, Mayo Hotel, Tulsa.
Oct.	
11–14	**NACE,** Northeast Region Conference, Prichard Hotel, Huntington, W. Va.
25–28	**NACE,** South Central Region Conference, Mayo Hotel, Tulsa.
Nov.	
16–20	**NACE,** General Florida Conference and Corrosion Short Course, Key Biscayne Hotel, Miami.
Dec.	
4- 7	**AIChE** Meeting, Hotel Statler, Washington.
7–11	**NACE,** University of Illinois Corrosion Control Short Course, Urbana Campus.



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Men In Industry...

Robert M. Woolfolk, Jr., has been appointed manager of manufacturing, Texas Gas Corp. He has been assistant manager of the Manufacturing Department since May 1959 after joining Texas Gas in 1957 as chief engineer. Woolfolk received his B.E. degree in chemical engineering in 1947 from Tulane University. He began his career with The California Co. as an engineer in New Orleans. He had previously been a division engineer for that company, responsible for all gas and processing operations in the Gulf Coast Division.

Woolfolk, Jr.

Donald J. Buckley has been appointed a senior research associate in the Chemicals Research Division, Esso Research and Engineering Co. The author of numerous technical articles of synthetic rubber and polymers, he was previously a section head in the Chemicals Research Division with responsibility for all research on applications of butyl rubber. Buckley joined Esso Research in 1942 after receiving B.S. and M.S. degrees in chemistry from Canisius College. He is a member of ACS and the New York Rubber group.

D. W. Devaney has been promoted to manager of industrial relations for Continental Oil Co.'s Southwestern Region, with headquarters in Fort Worth. He formerly was director of training for Conoco's Manufacturing Department, Houston. Devaney joined Conoco in 1949 as coordinator of training for Cit-Con Corp., Lake Charles, La., a company affiliate. He became director of training for the Manufacturing Department in 1957. A native of Dover, N. J., he is a graduate of Columbia University.

William H. Price has been named vice president of Cities Service Petroleum, Inc. Formerly a staff executive in the Manufacturing Department, in his new capacity he will be executive assistant to **A. P. Frame,** senior vice president of the parent company, in charge of manufacturing, research and petrochemicals. Price graduated from the University of Pittsburgh with a B.S. degree in petroleum refining. He joined the Cities Service system in 1924 and has been associated with the construction and operation of Cities Service refineries in various areas of the United States and Canada. He is a director of the Cities Service Refining Corp., Cities Service Research & Development Co., Petroleum Chemicals, Inc., and Cities Service Refining (Canada), Ltd.

Forrest N. Shumway has been named secretary of Signal Oil and Gas Co. A member of Signal's legal staff since 1957, Shumway became assistant secretary in that year and was named a director of the company in January 1959. Previously, he was an attorney for the County Counsel's Office for five years. Holder of B.A. and LL.B. degrees from Stanford University, he succeeds **A. E. Stebbings,** director, whose increasing duties as general manager of Signal's marketing department necessitated the change.

W. R. Cooper, Arabian American Oil Co.'s general manager for engineering and construction, has been elected a vice president of Aramco. He will assume responsibility for all engineering and construction activities of the company.

L. M. Snyder, who had been vice president in charge of engineering, construction and local sales, has been named vice president in charge of relations. Both men will headquarter in Dhahran, Saudi Arabia.

Thomas M. Lumly has resigned, for health reasons, as president of The Refinery Engineering Co. **Woodman Perine,** Vitro Corp. of America vice president, succeeds him. An engineering graduate of Oklahoma A. & M. College, Lumly has been in refinery engineering and construction for almost 20 years. He started in the refining industry as chief engineer of Cushing Refining and Gasoline Co. In 1936 he joined Cosden Petroleum Corp. as chief engineer and two years later organized Motor Fuels Corp. He later became general manager of the National Oil Proprietary, Ltd., in Australia.

Lumly

In 1942 Lumly organized The Refinery Engineering Co. which he served as president and majority stockholder. Since January, 1956, he has been president of Treco, and a director of Vitro Corp. of America.

Richard L. Cook has been named general superintendent in charge of all gas plants of Signal Oil and Gas Co. Cook, who has supervised operations of Signal's gas plant at Tioga, N.D., since 1954, joined the company in 1953 as a field engineer during construction of the plant. He will move to the company's Los Angeles headquarters to assume his new duties.

In an organizational change at the Tioga plant, **Harold Severson** has been named district manager in charge of the office. **Fred W. Norton** has been made superintendent of operations, and **Robert R. Dewell** will be in charge of operators and plant process.

Merwin Bristol has been elected a director and general counsel of Standard Oil Co. (Indiana). Formerly associate general counsel, he joined the company in 1921 in Denver when the Midwest Refining Co., with which he was associated, became part of Standard Oil. He transferred to the Chicago general office in 1923 as an administrative assistant. Bristol moved to the Law Department in 1926 as an attorney, became assistant general counsel in 1953 and associate general counsel in 1957. A native of Cheyenne, Wyo., he is a 1922 law graduate of the University of Denver.

C. E. Starr, Jr., has been appointed a deputy coordinator, an executive post in the General Administration Unit of Esso Research and Engineering Co. In this capacity, he is responsible for consolidation of certain supporting activities presently carried out by various divisions. Starr began his company career at the affiliated Esso Research Laboratories in Baton Rouge in 1936, eventually becoming assistant director. He transferred to the Linden laboratories in 1951 and became public relations manager. Two years ago he was named manager of technical and public information. Starr graduated from Massachusetts Institute of Technology with a B.S. degree in chemical engineering, and was once an instructor in chemistry at the University of Miami.

Paul C. Pearson, Jr., has been appointed manager of the Newark, N.J., plant of Celanese Plastics Co., an operating division of Celanese Corp. of America. A native of Butte County, Calif., and 1942 graduate of Guilford College, he had been manager of the Celanese chemical plant at Point Pleasant, W. Va. He joined Celanese in 1942 as a chemist at the Cumberland, Md., fibers plant. In 1945, Pearson transferred to Bishop, Texas, where Celanese had just completed its first chemical plant. He served in various supervisory positions in the Production Department until he was made assistant to the plant manager of the Point Pleasant plant.

J. Prince Warner has been elected to the Esso Standard Oil Co. board of directors. Esso's general manager of manufacturing, he was elected a vice president in August. Warner has been general manager of manufacturing since January 1956. He was formerly general superintendent of the company's Baltimore and Baton Rouge refineries, and assistant general manager at Baton Rouge, where he began his career with the company in

Warner

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Men . . .

1929. A graduate of Massachusetts Institute of Technology, he was on the instructing staff there before joining Esso.

Dr. Robert Henry Salvesen and Ernest V. Haines have joined the staff of Esso Research and Engineering Co. Before joining Esso Research, Dr. Salvesen was with Socony Mobil Oil Co., Inc., in Brooklyn for seven years. He attended Wagner College where he received a B.S. degree in chemistry. He earned his M.S. degree in chemistry at the University of Buffalo and his Ph.D. degree at Polytechnic Institute of Brooklyn.

Haines was manager of the Patent Department of International Minerals and Chemical Corp., Skokie, Ill., for 13 years before joining Esso Research. He received his B.S. degree in chemistry from the University of Maryland and LL.B. degree from Georgetown University.

Louis Mittelman, Tidewater Oil Co., has been named superintendent, technology, control laboratories and budget, Avon refinery. He joined Tidewater in 1921 as a chemist at Avon, became the refinery's assistant chief chemist in 1926, and in 1927 was promoted to chief chemist at Tidewater's Western Manufacturing Center. He holds a B.S. degree in chemistry from Cornell University.

Lewis A. Penn succeeds Mittelman as chief chemist at Avon. He joined Tidewater in 1920 as a refinery chemist, in 1929 became supervisor of the chemistry laboratory at the west coast manufacturing plant, and in 1936 was promoted to assistant chief chemist. Penn received a B.S. degree in chemistry from the University of California at Berkeley.

D. L. Fridley and G. W. Lowe are new members of the Technical Division at Humble Oil & Refining Co.'s Baytown, Texas, refinery, and **W. S. Vorhaben** returns to the company from military service. **J. K. Nickerson** and **B. G. Corman** have joined the Research and Development Division.

William H. Montgomery, general manager of employe relations of Socony Mobil Oil Co., Inc., for the past 12 years, has been appointed general manager of the Manufacturing Department of Mobil Oil Co. After entering the oil industry in 1926 at Bayway, N. J., Montgomery was assigned two years later to overseas service at the Palembang refinery on Sumatra, in what was then the Dutch East Indies and is now Indonesia. The refinery became a part of the Standard-Vacuum Oil Co. when that firm was established in 1933.

Montgomery

He was assistant general superintend-

ent of the refinery when he left Palembang in 1941. He returned to the United States in December to join Socony Mobil's Lubrite Division in East St. Lou's, Ill. He became refinery manager there in June 1943. Montgomery graduated from Grove City College in 1924 as a chemical engineer and taught chemistry for a short time in Grove City, Pa., schools.

Stephen Valentine, formerly with the Engineering Department of Socony Mobil Oil Co., has joined the company's Process Promotion Department as a senior engineer. Valentine received his B.S. degree in engineering from Princeton University in 1947. He joined Socony Mobil on a part-time basis in 1948 and became a full-time employe after receiving his M.S. degree at Princeton University in 1947. He joined Socony Mobil on a part-time bas's in 1948 and became a full-time employe after receiving his M.S. degree at Princeton in 1949. He worked in the Refinery Engineering Division of Socony Mobil from 1949-52, then joined the Operating Section in the division and helped start up new units. Since 1954, he has been in design work in the Engineering Department.

Valentine

Benjamin M. Holt has been named sales manager for the Engineering and Construction Division, Southwestern Engineering Co. He will direct sales of the company's engineering and construction services. Holt's prior associations during more than 20 years' experience in sales and engineering management include American Potash & Chemical Corp., The Ralph M. Parsons Co., and Union Oil Co. of Calif. He is a member of AIChE and holds a B.A. degree in chemistry from Stanford University and M.S. degree in chemical engineering from Massachusetts Institute of Technology. He is a registered chemical engineer in California.

Seymour W. Ferris has been appointed a research associate on research and development by Sun Oil Co. He will explore new products and new ways to utilize existing products. A graduate of Cornell University, Ferris received a B.S. degree in chemistry in 1922. He was with Atlantic Refining Co. from 1923 until he joined Sun Oil in 1945 as a chemical engineering supervisor in research and development. He was promoted to section chief of waxes, product development, in January, 1948. He became chief of industrial products in May 1953. Ferris is a member of ACS, American Association for the Advancement of Science, New York Academy of Science, ASTM, and Franklin Institute in Philadelphia. He is a licensed professional chemical engineer in Pennsylvania. He holds more than 40 patents and has

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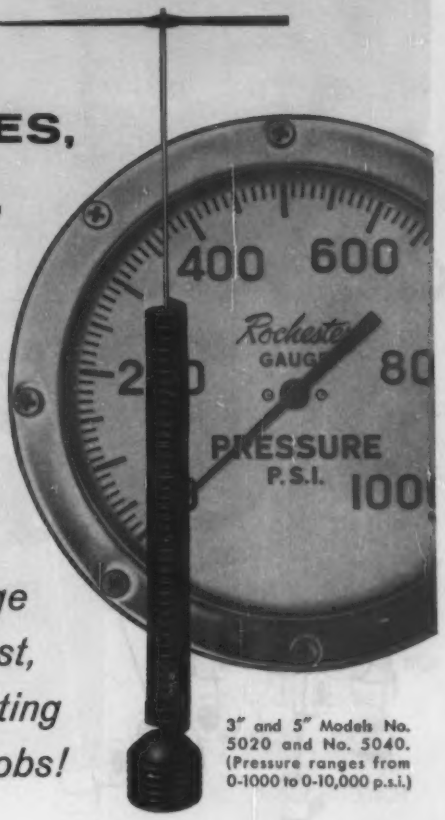

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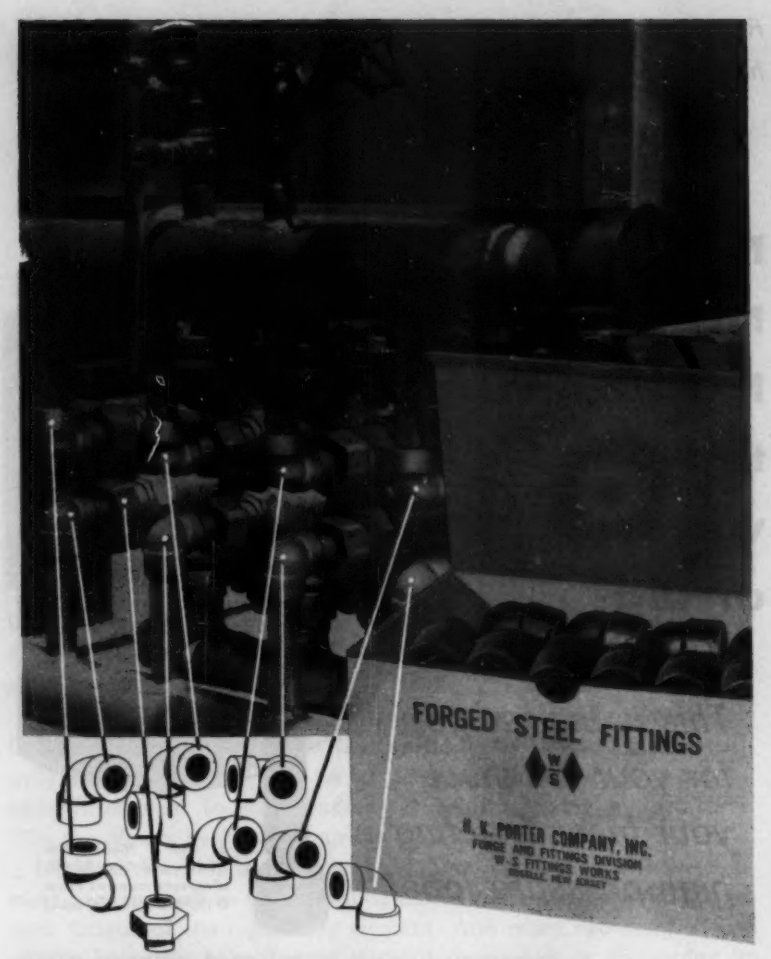

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Men . . .

written 25 technical articles on petroleum.

Ivor W. Mills was appointed to succeed Ferris as section chief for industrial products in Product Development. He started with Sun Oil as a chemist in research and development after graduation from Lehigh University with a B.S. degree in chemistry in 1935. He was named a group leader in 1947, his position at the time of his recent promotion.

He is a member of the American Association for the Advancement of Science and ACS.

J. A. Golasinski has been named manager of Shell Oil Co.'s Houston area Gas Department. With the department 22 years, he has served as superintendent of operations in Houston since 1954. Holder of a B.S. degree from Texas A&M College, he joined Shell in 1937 at its Iowa, La., gas plant, and later transferred to the Magnolia, Ark., plant. After World War II military service, he returned to Shell as a gas tester at Houston. He later became a gas engineer and in 1950 moved to the Sheridan, Texas, plant, where he served as gas engineer, assistant plant superintendent and later district superintendent.

Golasinski

John P. Purcell has been named operations coordinator in the Eastern Region office of Du Pont's Petroleum Chemicals Division, New York. In this capacity, he will coordinate services related to the safe and efficient handling of tetraethyl lead and other petroleum additives.

Robert B. Bothwell, who has been operations coordinator in the Eastern Region, has been transferred to the division's Gulf Coast Region as a sales service representative in the Houston area, while **Richard R. Golding** has moved to the division's headquarters in Wilmington as a technical assistant to the Operations Section. Golding has been sales service representative in the north Jersey area.

A. C. Rose, Jr., associate director of the Louisiana Petroleum Council, Baton Rouge, for the past year, has resigned to become executive vice president, Colorado Petroleum Committee, Denver. A graduate of the University of Missouri School of Journalism, Rose previously served three years as senior district representative for the former Oil Information Committee of the API in charge of the New Orleans office, serving both Louisiana and Arkansas. He joined the Oil Information Committee staff in 1954 as a district representative in Kansas and Oklahoma with offices in Tulsa and was promoted to the New Orleans position in November 1955. He was previously direc-

Because only Jenkins
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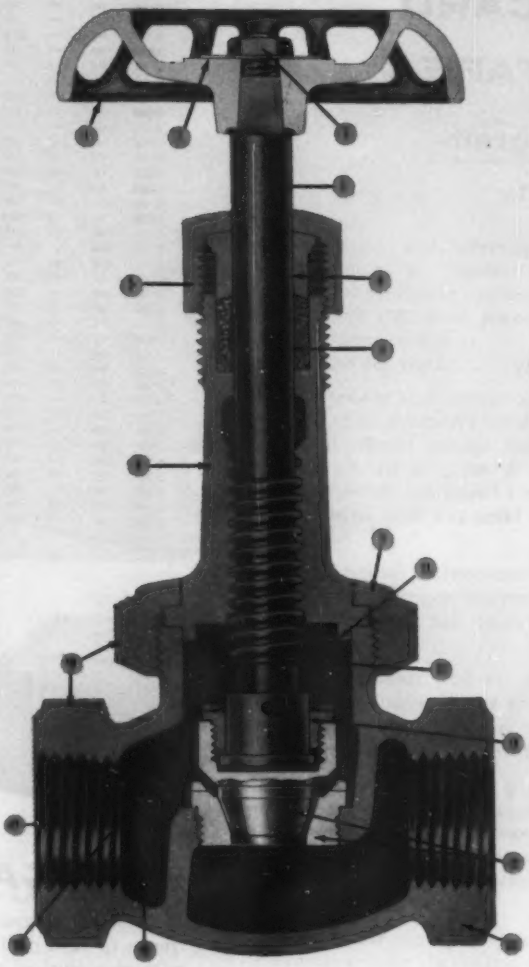
Specify JENKINS for PLUG TYPE Bronze Valves, too

THROTTLED STEAM with its destructive erosive effect on a valve seat . . . hard, seat-cutting substances like rust tubercles, boiler scale, pipe chips . . . such valve destroyers have little or no effect on a Jenkins Bronze Plug Type Valve. Jenkins 500 Brinnell Armor Seat defeats them.

There's much more to the durability of these valves than the seat. Jenkins gives you 17 *other* superior features that contribute to long-life and completely satisfying service. All are important to any valve user who wants maximum economy, and only Jenkins gives you all of them. Send for literature which gives full details about them.

Still more protection against valve repairs comes from superiorities which cannot be seen in any picture of a valve: The quality in the castings . . . the precision machining . . . the rigid inspection and testing which every Jenkins Diamond-marked valve undergoes.

You have many sound reasons for specifying Jenkins when the service calls for PLUG TYPE Bronze Valves. And you pay no premium for them. Write us or ask your Jenkins distributor for information folder.



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14. LOCKNUT
15. FULL DIAPHRAGM-SHELL CLEARANCE
16. LIBERAL DIAPHRAGM WALL CLEARANCE
17. FULL LENGTH PIPE THREADS
18. EXTRA HEAVY BRONZE BODY

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Send folder No. 202-A describing Plug Type Bronze Valves

Name & Title.....

Company.....

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For more data on advertised products, use Readers' Service Cards, last page.

TWO NEW LOW-COST SYSTEMS IBM 1401 CARD... IBM 1401 TAPE

with stored program speed and ability

Never before has so much powerful data processing ability been built into such low-cost systems! For in these two new IBM 1401 Systems you get features previously found only in the larger data processing systems. With 1401 Systems fewer machine units do *more* jobs . . . at *higher* speeds . . . with *greater* accuracy and reliability . . . at *lower* job cost.

To assure you of more production per data processing dollar, IBM's concept of Balanced Data Processing gives you compatible input, processing and output speeds, backed by unequalled customer service. Drawing on all the experience gained in developing the world's largest and fastest computers, these low-cost 1401 Systems bring you these large computer features:

Solid State Design—and transistorized throughout to give you a compact system with greater accuracy and reliability. This powerful system involves no special construction . . . no air conditioning.

Stored Program—gives you the fully automatic processing of electronic systems. It is the key to simplified, economical operation. Completely flexible, a stored program permits you to switch easily from one type of job to another.

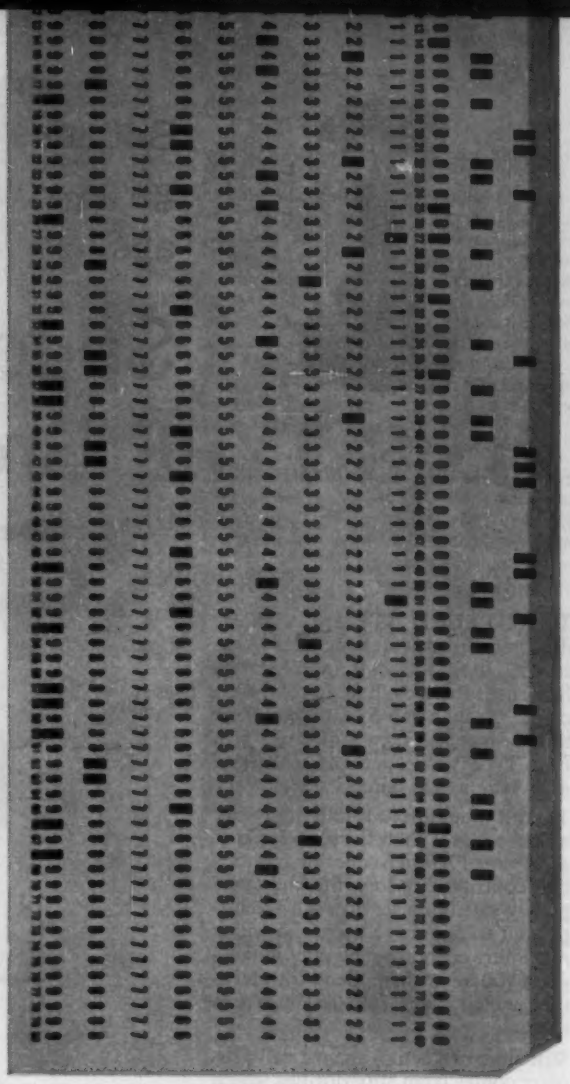
Magnetic Core Storage—the most powerful type storage available. To increase this power even further, the core memory of the 1401 accepts variable-length data and instructions, to permit the storage of only useful information. Choice of 1400, 2000, or 4000 positions of storage means you select the size storage to suit your needs.

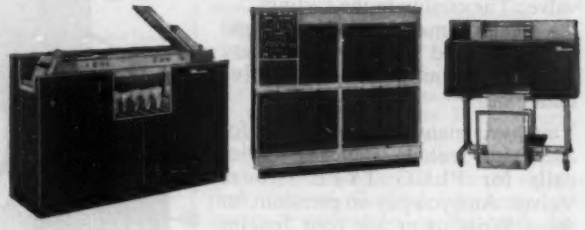
High-Speed Printing—these 1401 systems feature an exclusive new concept of printing. A horizontally rotating chain prints high-quality, perfectly aligned copy. A dual-speed carriage permits printing at the rate of 600 lines a minute, skipping blank paper at 27,000 lines per minute to produce more documents per dollar. Completely flexible editing and print format is provided by the central processor.

Your local IBM representative will explain the many applications and unusual features of the new 1401 Systems. Call him today. These systems, like all IBM data processing systems, may be purchased or leased.

BALANCED DATA PROCESSING

IBM





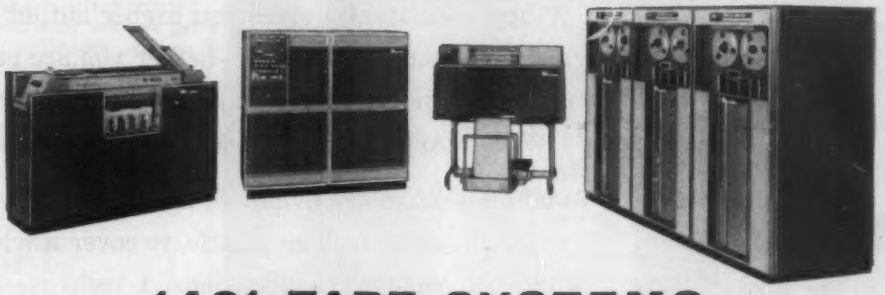
1401 CARD SYSTEMS

These stored program systems now bring the power of electronics to IBM card systems. They automatically handle the work of accounting machine, summary punch, and calculator, but at far greater speed, and with more flexibility and accuracy.

Input is faster—IBM cards are read into the system at the rate of 800 per minute. Data is processed automatically under stored-program control. Manual card handling is minimized.

Output is faster—documents are printed at the rate of 600 lines per minute, cards punched at 250 per minute. The system will turn out, for example, as many as 230 checks in one minute—again, more documents per dollar through Balanced Data Processing!

Thru-put is faster—data flow is automatically checked for accuracy and speeded all along the line. A unique Card Read-Punch combines card input, output, and summary punching functions. Five radial stackers accept cards that are selectively separated under stored program control.



1401 TAPE SYSTEMS

IBM 1401 Tape Systems give you added power through use of up to six magnetic tape units. These units feed data into the system at the rate of up to 62,500 characters per second . . . record processed results at this same peak speed.

1401 Tape Systems are also extremely valuable as off-line auxiliaries to large data processing systems. They can edit tapes prepared for larger IBM systems. They make possible a tape-oriented IBM 7070 configuration that provides higher speed input and output and makes for job cost improvement.

When tape units are added to 1401 Systems, you get greater flexibility and storage advantages, too. IBM tapes provide extremely compact storage of variable-length records—the equivalent of 129,000 IBM cards on a single reel. Tape records can be of variable length, and are read into and out of the system automatically. Also, tapes can be erased and re-used to minimize your record-keeping costs.

HARD TO HANDLE?
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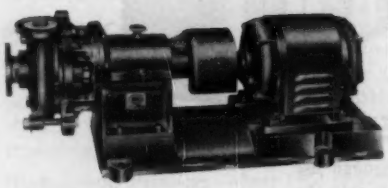
ACID PUMPS

Pumping hot corrosive liquids *efficiently* is standard practice for Wilfley Acid Pumps. Even under the pressure of 24 hour-a-day schedules Wilfley pumps continue to deliver trouble-free performance. Actual production records prove Wilfley consistently gives you higher output and lower pumping costs. Whether you are pumping corrosives, hot liquids or mild abrasives, there's a Wilfley Acid Pump that will do the job for you.



Pumping parts are available in a variety of metal alloys, as well as plastic, to cover a wide range of corrosive applications. 1 inch to 8 inch discharge sizes with 10 to 3000 GPM capacities and heads up to 200 feet.

Write, wire or phone for complete details.

Individual Engineering on Every Application

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"COMPANIONS IN ECONOMICAL OPERATION"
WILFLEY SAND PUMPS

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Men . . .

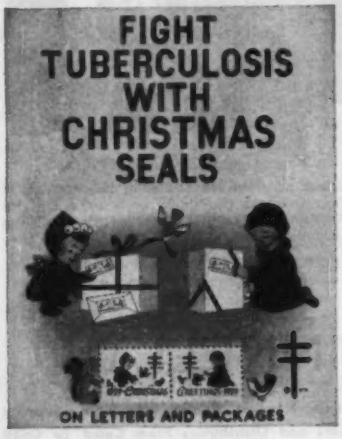
tor of public relations for Kansas State Teachers College, and a member of the editorial staff of the *Owensboro Messenger and Inquirer*, Owensboro, Ky.

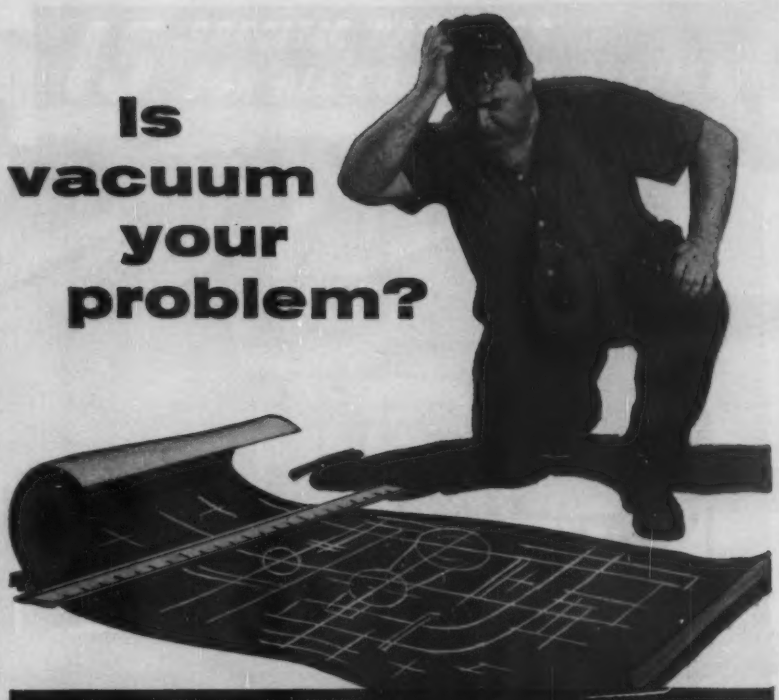
David F. Edwards has been named employe relations manager for Humble Oil & Refining Co. Previously manager of Esso Standard Oil Co.'s Bayonne, N. J., refinery, he was named assistant general superintendent of the plant in 1953, general superintendent in 1955 and manager in 1957. Earlier he had been assistant process superintendent, assistant head of the Technical Division and assistant head of the Petroleum Products Division, Baton Rouge refinery. He joined the company in 1926 in Pittsburgh, where he was working for a Ph.D. degree in chemistry.

Edwards

Dr. Wladimir Philippoff has joined Esso Research and Engineering Co., as a research associate, Products Research Division. Formerly with the Franklin Institute Laboratories, he came to the United States from Germany in 1958 and became a research fellow at Stanford University for a year. After two years as a research associate with the University of Minnesota School of Mines, Dr. Philippoff became principal scientist and head of the rheology branch at Franklin Institute Laboratories, Philadelphia.

Mario W. Polak has opened an engineering-consulting firm, Guardian Engineering Co., Ltd., Calgary, Alb., to serve the Western Canada oil, natural gas and manufacturing companies. His experience is in design and engineering work on gas gathering systems, compressor stations, processing and treating plants, power generation and industrial manufacturing plants. Polak is a graduate of Leeds University, England, and an active member of ASME, the Institute of Petroleum, Canadian Gas Association, ASTM, Canadian Institute of Mining & Metallurgy





Here's the solution to a big one — —

—Graham Twin Two Stage Non-Condensing Ejector handling 38,000 pounds per hour of non-condensibles at 2" hg. abs. pressure (124,000 CFM).

Graham offers you over a quarter century of experience in building ejectors from one to seven stages in every conceivable combination.

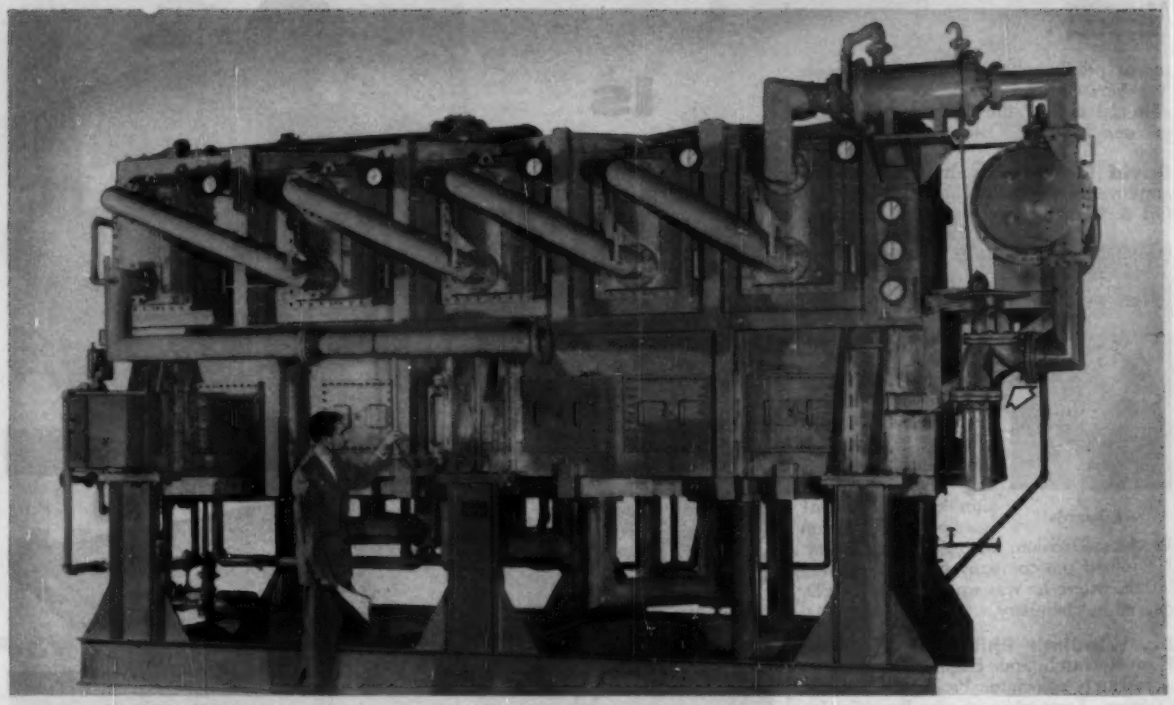
Let us help you with your vacuum problems: Factory trained engineers are available in these cities:

Baltimore, Md.	Miami, Fla.
Boston, Mass.	Minneapolis, Minn.
Buffalo, N. Y.	Mobile, Ala.
Chicago, Ill.	Philadelphia, Pa.
Cincinnati, O.	Pittsburgh, Pa.
Cleveland, O.	Richmond, Va.
Denver, Colo.	Roanoke, Va.
Detroit, Mich.	San Francisco, Calif.
Houston, Tex.	Santurce, Puerto Rico
Kansas City, Mo.	Seattle, Wash.
Los Angeles, Calif.	St. Louis, Mo.
Mexico, D.F., Mex.	Toronto, Ont.
	Tulsa, Okla.

GRAHAM MANUFACTURING CO., INC.
Heliflow Corporation
170 GREAT NECK ROAD, GREAT NECK, N. Y.

Factory: Batavia, N.Y. Other Graham precision-built products: Steam Jet Ejectors, Monobolt Heat Exchangers, Deaerating Heaters, Surface and Barometric Condensers, Steam Vacuum Refrigeration, Aquamizer Evaporative Condensers.

For more data on advertised products, use Readers' Service Cards, last page.



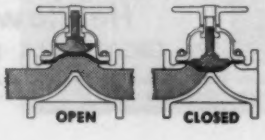
ON LAND At Salinas, a tourist center in Ecuador, this Cleaver-Brooks Flash Evaporator delivers 50,000 gallons of pure, distilled water every 24 hours. It is equipped with two 6", rubber lined, weir-type Grinnell-Saunders Diaphragm Valves — only one of which can be seen from this view.

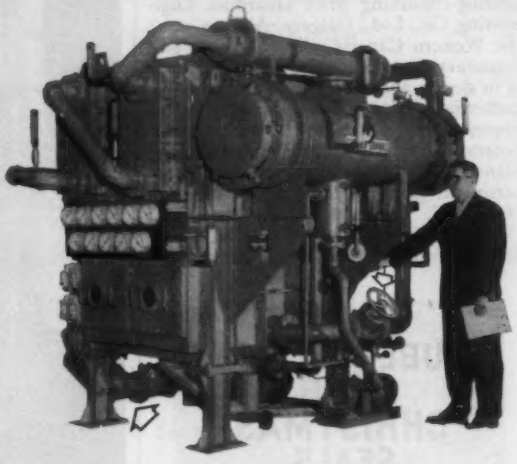
Grinnell-Saunders Diaphragm Valves help convert salt water to fresh water

You can convert sea water to fresh water, in abundant supply, on land . . . or on shipboard, with flash evaporators made by Cleaver-Brooks Special Products, Inc., Waukesha, Wisconsin. Grinnell-Saunders Diaphragm Valves are used as original equipment on these distillation units because they offer positive, leak-tight closure; flow control in throttling position; corrosion-resistance.

You'll find Grinnell-Saunders valves widely used in other fields, too . . . petroleum, papermaking, chemical, food, compressed air . . . to mention a few.

The operating principle of the Grinnell valve is the feature which makes it so adaptable. The diaphragm lifts high for streamline flow in either direction; seals tight for positive closure against grit, scale, solid matter, pressure or vacuum. Bonnet mechanism is completely isolated at all times from the fluid in the line by the diaphragm, preventing corrosion and contamination. Smooth passage, without pockets, eliminates trapping of solids and reduces frictional resistance. And you can get body, lining and diaphragm materials to meet your particular service conditions. Get *all* the facts. Write Grinnell Company, Providence 1, R. I.





AT SEA The nuclear powered NS Savannah has two 16,000 gallons-per-day Cleaver-Brooks distillation units to supply the entire water requirements of crew and machinery. Each unit has two 4" Grinnell-Saunders Straightway Valves of ductile iron.

GRINNELL

Pipe, Fittings, Valves, Hangers, Heating and Piping Supplies
Branch Warehouses and Distributors From Coast To Coast

Men . . .

and several other technical societies. Guardian Engineering will concentrate heavily on natural gas processing plants and the design of pressure vessels and equipment.

Dr. Bernard J. Lerner, a chemical engineer, has opened a consulting office in Pittsburgh, specializing in research and development problems of the petroleum and petrochemical fields. Most recently group leader of the Chemical Engineering Research Group at Gulf Research & Development Co., Dr. Lerner was also an assistant professor at The University of Texas.

Harry R. Miller, 53, labor relations manager for Standard Oil Co., of Calif., died of a heart attack recently while on a business trip to Perth Amboy, N. J. He joined Standard's Producing Department in 1927 and shifted to personnel work during World War II. He joined the labor relations staff in 1943 and was named assistant manager in 1955. Three years later he was appointed manager. Miller is survived by his wife, a daughter, a sister and a brother.

William C. Hildebrand has been named vice president of Bay Petroleum Co. In the petroleum industry in the Houston area for many years, from 1923-45 he was employed by a number of oil companies in capacities ranging from salesman to vice president. In 1945, he helped form and became vice president of Anchor Oil Co., later known as Gordon-Hildebrand, Inc. Hildebrand liquidated his interest in this company in 1956. In 1951, with a group of associates, he formed Processors, Inc. and became its president. He retained this interest until August 1959, when the company's assets were sold. From 1951 to September 1959, Heldebrand served also as Texas agent for Oil and Chemical Products, Inc., New York.

Hildebrand

R. C. Faulkner, director of mechanical design and construction in the Pittsburgh office of Gulf Oil Corp., has retired. With Gulf since 1923, he joined the company at Port Arthur after graduating from Texas A & M College. In 1945, Faulkner was made general superintendent of refineries in Texas, a title that was later changed to general manager, with full re-

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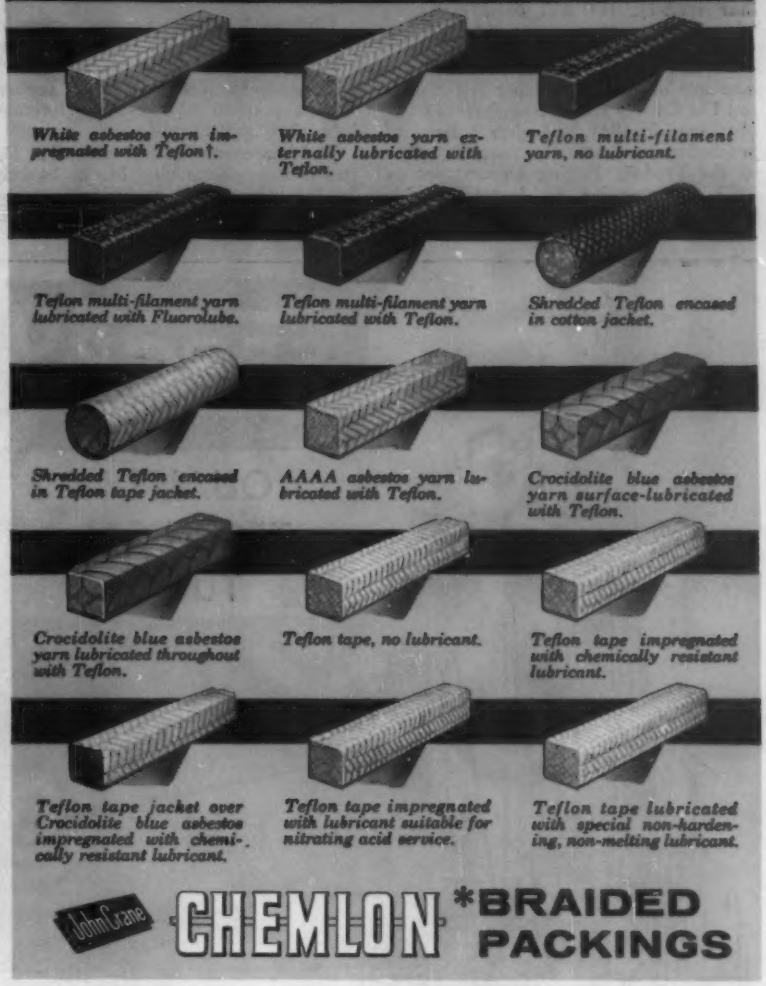
15 SPECIFIC PACKINGS FOR ALL CORROSIVE SERVICES


White asbestos yarn impregnated with Teflon†.
White asbestos yarn externally lubricated with Teflon.
Teflon multi-filament yarn, no lubricant.
Teflon multi-filament yarn lubricated with Fluorolube.
Teflon multi-filament yarn lubricated with Teflon.
Shredded Teflon encased in cotton jacket.
Shredded Teflon encased in Teflon tape jacket.
AAAA asbestos yarn lubricated with Teflon.
Crocidolite blue asbestos yarn surface-lubricated with Teflon.
Crocidolite blue asbestos yarn lubricated throughout with Teflon.
Teflon tape, no lubricant.
Teflon tape impregnated with chemically resistant lubricant.
Teflon tape jacket over Crocidolite blue asbestos impregnated with chemically resistant lubricant.
Teflon tape impregnated with lubricant suitable for nitrating acid service.
Teflon tape lubricated with special non-hardening, non-melting lubricant.

John Crane CHEMLON *BRAIDED PACKINGS

Specific service conditions are always best handled with a packing designed for the purpose. This is especially true when it comes to hard-to-handle liquids in pumps, valves, agitators, mixers, plating equipment and similar applications.

For this reason John Crane has developed 15 individual field-proved types of Chemlon Braided Packings. Within this line there is a type and style that will meet any combination of service conditions and requirements.

1. All known industrial acids, alkalis or solvents.
2. Temperatures from −120°F to +600°F.
3. High or low shaft speeds, also valve stems.
4. Longer packing life due to lower coefficient of friction and non-raveling construction.

Send in your service condition and we will recommend a Chemlon Braided Packing best suited to your application. Request Bulletin P-325.

Crane Packing Co.. 6420 Oakton St., Morton Grove, Ill.(Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

†*T. M. for DuPont Teflon* *T. M. for the Best in DuPont Teflon

CRANE PACKING COMPANY

For more data on advertised products, use Readers' Service Cards, last page.

Men . . .

sponsibility for operation of the Port Arthur refinery. He had been in Gulf's Manufacturing Department since 1957.

Wallace E. Frasier has been named manager of product pricing for American Oil Co. He joined Standard Oil Co. (Indiana) in 1941, and after a series of promotions, was named account manager of the Product Pricing Department in 1955. He attended St. Joseph's Junior College and Kansas University and served with the U. S. Navy from 1944-46.

George D. Watson has been appointed shift foreman, reforming and cracking, Tidewater Oil Co., replacing **T. J. Vacchieri** who is retiring.

Clifford A. Torbet becomes operating foreman, solvent treating and light oil treating.

Kenneth H. Bisordi assumes Torbet's former position of operating foreman, lube crude and blending.

In Maintenance and Construction Department appointments, **M. S. Stokely, Jr.,** has been named machinery inspector and **D. H. Emanuelson** becomes area engineer, replacing Stokely.

SERCK

QUALITY TECHNICAL TUBES

A 50,000 gall./day evaporator for a refinery under construction by Procon (Great Britain) for Anglo Ecuadorian Oilfields, Ltd., being tubed with SERCKALBRA.

(Photograph by courtesy of Richardson, Westgarth and Co. Ltd.)

for the OIL INDUSTRY

SERCKALBRA (ALUMINIUM BRASS)
SERCKCUNIK (CUPRO-NICKEL)
ADMIRALTY BRASS
ALUMINIUM BRONZE
70/30 BRASS

Serck Tubes Limited, Warwick Road, Birmingham 11, England

A member of the Serck Group.

Ray H. Horton, vice president and director of Humble Oil & Refining Co. of Texas, has been named president of the Humble Division of the new Humble Oil and Refining Co.

Also on the division board of management will be **Ralph J. Schilthuis,** as executive vice president; **Herman P. Pressler,** as vice president; **Ed J. Hamner, James H. Galloway** and **Russel H. Venn,** as members, and **Carl Illig,** as member and general counsel.

Donald K. Ballman and **C. B. Branch** have been elected vice presidents of The Dow Chemical Co. The board also elected **Robert B. Bennett** treasurer and **Fred H. Brown** controller.

A. L. Anderson has been promoted to research group leader in Continental Oil Company's Research and Development Department, Ponca City, Okla. He will serve in the Petroleum Products Division. Anderson has been with Conoco's Research and Development Department since 1952. Previously he served two years at Conoco's refinery laboratory at Lake Charles. He has a B.S. degree in chemical engineering from the University of Minnesota.

– Deaths –

James O'C. Brown, 62, vice president of Petro-Tex Chemical Corp., and a veteran of over 43 years in the petroleum and rubber industries died in Houston October 2 after a prolonged illness. Brown joined Sinclair Refining Co. in 1916 at its Mereaux, La., refinery, and advanced through various operating levels to become superintendent of the Lube Oils Division, Sinclair refinery, Houston, 1923. In July 1942, at the outset of the GR-S program, he was chosen general superintendent of Sinclair Rubber, Inc., created to operate the government-owned butadiene plant at Houston. Brown was named manager of the plant in 1950, continuing in that capacity after acquisition of the Sinclair butadiene facility from the government by Petro-Tex. He was elected a vice president of Petro-Tex in October 1956.

Brown

Capt. H. R. Adams died September 6 at the hospital in Upper Darby, Pa. Prior to his retirement a year ago, he was Sinclair Refining Co.'s marine manager. In 1909, he enlisted in the U.S. Navy, served for 12 years, and in 1921 joined Sinclair as third mate. He was made master in 1925 and port captain in 1937 after serving on various Sinclair tankers. In 1943, he was recalled by the U.S. Navy and commanded various naval transports until the end of World War II. He rejoined Sinclair in 1946 as manager of operations and in 1951 was appointed marine manager.

POSITIVE CONTROL

at high TEMPERATURES

Motor Operated for Remote Control

CUT HIGH MAINTENANCE COST— Install WEDGEPLUGS

- **No Lubricants Required** for absolute control. Plug Lifts, Turns and Reseats in one quick, easy operation.
- **Non-Sticking**—No field adjustment necessary for variable temperatures.
- **Seats are Protected** against valve-killing erosion of dry and fluid catalyst.
- **Wedgeplugs Have Proven Themselves** to be top performers on such services as hydrocarbon vapors at 900°F. and 600 psi; fluid catalyst at 1125°F. and 255 psi; and, hydrogen at 900°F. and 300 psi.

SOLD THROUGH DISTRIBUTORS IN EVERY MAJOR CITY

Can be supplied: wrench-operated; handwheel-operated; worm gear-operated. Adapted for remote control through use of electric, hydraulic or air motor.

For complete catalog information, write to 4033 North 10th Avenue

WEDGEPLUG VALVE COMPANY
Division of
STOCKHAM VALVES & FITTINGS
GENERAL OFFICES AND PLANT • BIRMINGHAM 2, ALA.

WEDGEPLUG
NON-LUBRICATED
STEEL PLUG VALVES

DESIGN ELIMINATES NEED FOR LUBRICATION

268 ACRES OF PLANT

This huge petrochemical installation was engineered and constructed by Chemico—working with the client's own technical staff. The facilities cover approximately 268 acres. Designed to utilize the client's own processes, this mammoth, integrated plant was completed by Chemico with a minimum of difficulties and delays. Details of the project were given the closest attention by an organization geared to handle the biggest and most complex chemical and petrochemical process installations.

In the field of general process engineering, few can match Chemico's remarkable record of achievements. Consult Chemico before you decide. Write today for a copy of the new Chemico general bulletin.

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Suppliers Notes...

Lamberth

Woltz

Tom M. Lamberth, Jr., has been promoted to assistant to the Southwest district manager, The Cooper-Bessemer Corp. **Clifton W. Woltz** has been appointed branch manager of the Shreveport office. A mechanical engineering graduate from Texas A&M College, Lamberth had been sales engineer with Joseph A. Coy Co. and Arrow Industrial Manufacturing Co. before joining Cooper-Bessemer. Woltz had been sales engineer at the Dallas office before his promotion to branch manager, Shreveport office. A graduate of Case Institute of Technology, he has a B.S. degree in mechanical engineering.

E. C. Meisner has been named Division Vice President, The Philip Carey Manufacturing Co. He was previously general manager of the Insulation Division, Plymouth Meeting, Pa. Before joining Carey in 1955, Meisner spent eight years at Crosley Division, AVCO Manufacturing Corp., Cincinnati, as a chief industrial engineer, works manager and general manager. He also served eight years at National Cash Register Co., Dayton, Ohio, as assistant metallurgist, assistant to plant manager, and department head of manufacturing processes, tool planning and physical testing laboratory.

Meisner

Robert L. Allen has been named president of the Solar Chicago Division of U.S. Industries, Inc. He has been general sales manager of the Solar Chicago Division for two years, prior to which he held the same position with Fritz W. Glitsch & Sons, Inc., Dallas. A graduate of the Stanton Military Academy and Pennsylvania State University, he was a captain in the armored forces of the U.S. Army during World War II.

Allen

Cole H. Pilcher has been elected vice president of industrial relations by ACF Industries, Inc. He previously spent 18 years with Sylvania Electric Products, Inc. He joined Sylvania as assistant to the manager of employment and training, progressing to supervisor of personnel policy and research, industrial relations counsel, assistant director of industrial relations and, in 1954, director of industrial relations. He was elected a vice president in 1958. Pilcher will be responsible for organization, wage and salary administration, security and safety, employe benefits, and labor relations. He is a graduate of Williams College where he majored in psychology and philosophy. He received his LL.B. degree at Northwestern Law School in 1944.

Edmund W. Dugan has been named to head a Washington, D. C., office established by Chemetron Corporation. Located in the Moreschi Building, 905 16th St., N.W., it will handle business in Washington for the Chicago-headquartered corporation, subsidiaries and affiliate companies. Dugan was previously business manager for Chemetron's Girdler Catalysts operation in Louisville, Kentucky.

George E. Hulse has been named director of the newly formed Research and Development Department of Chemetron Corp.'s Chemical Products Division. From his headquarters at Rock Hill Laboratory, Newport, Tenn., Hulse will coordinate research and development activities for the division, which includes Holland, Color and Chemical Co., Holland, Mich.; Dunham Chemical Co., Chicago; Girdler Catalysts, Louisville, Ky., and the Crestwood Chemicals operation at Newport. Hulse has been with Spencer Chemical Co. as director of plastics research since 1955. He had previously been in chemical research for Hercules Powder Co. and the U.S. Rubber Co.

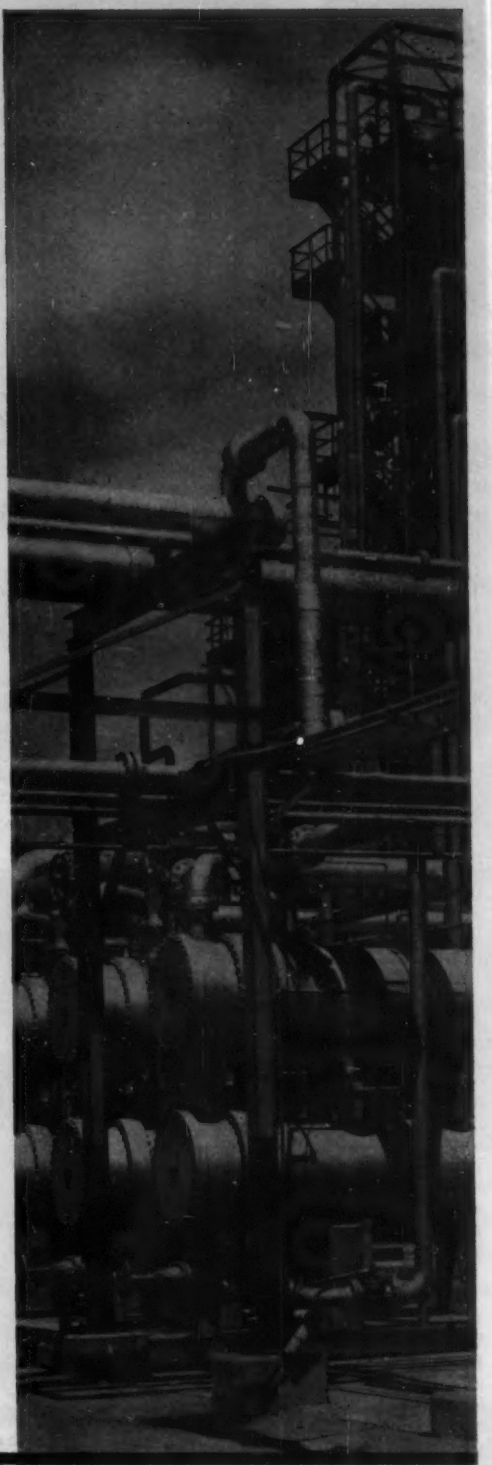
Hulse

Raoul D. Elder has beeen named division sales manager of Aurora Pump Division, The New York Air Brake Co. He joined Aurora Pump in 1953 after serving with the U. S. Air Force. Since then, he has acquired experience in the field and in the plant, serving as export sales manager and district sales manager.

This giant Union Dome, 10 stories high and comparable in area covered to a major league baseball diamond, is under construction for Union Tank Car Company in Wood River, Ill. The all-steel structure will be 380 feet in diameter and will rise to a height of 120 feet (when completed) similar in size to the world's largest circular building constructed by Union Tank Car Company in Baton Rouge, La., last year. Design and construction of the Wood River Dome are under the supervision of Graver Tank & Mfg. Co., a division of Union Tank Car Company. The dome will have no hindering internal supports whatever and will encompass 110,000 square feet of floor area when completed. The connecting paint tunnel (foreground) will be 200 feet long, 40 feet wide and 20 feet high. The Wood River Dome is being constructed of 804 steel panels, prefabricated by Graver Tank at its East Chicago, Ind., plant. Like its sister dome in Baton Rouge, the Wood River Dome will serve as a regional tank car repair and maintenance facility for Union Tank Car Company.

Oakite ECP
engineered cleaning program

saves tube bundles from scrap heap



Partially plugged with heavy soils after eight years of service, a series of coolers were marked by "Inspection Department" for the refinery scrap pile. Efforts to restore them with circulating acid had been fruitless.

Then, the refinery called in an Oakite engineer. He developed an ECP. For the coolers, it called for circulating a hot solution of Oakite Composition No. 19 under pressure, followed by hot and cold water rinses. In just a few hours, the condensers were completely clean and good for many more years of service.

WHAT IS OAKITE ECP? It's an *Engineered Cleaning Program* that stresses chemical cleaning. It's engineered specifically for your refinery, for your cleaning problems, and for each cleaning operation—tower by tower, valve by valve.

The Oakite engineer lends personal and experienced supervision to each phase of the program. He supplies detailed instruction based on practical knowledge of refinery cleaning needs. Each Oakite ECP is backed by a *laboratory* concentrating on chemical cleaning research, by *materials* known to make short work of refinery soils, by proved *methods*. Send for booklets. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE
SCIENCE

In our 50th year.

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Oakite ECP
your economy key

Suppliers . . .

MONSANTO CHEMICAL CO. has named **Edwin T. Richard** manager, marketing research, in the Inorganic Chemicals Division's Marketing Department. Richard holds a B.S. degree in chemical engineering from Massachusetts Institute of Technology and a M.B.A. degree in manufacturing from Harvard Business School. He has served for several years in the Marketing Research Department, U. S. Steel Corp., Pittsburgh.

THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS CO. has named **Walter A. Dienhart, Jr.,** a computer programer and analyst, TRW Products systems engineering office, Atlantic City. He received his B.S. degree in mathematics from Michigan State University in 1952, and has held engineering and programming positions with Bell Aircraft Corp., Lockheed Aircraft Corp., Cook Research Laboratories, Inc., and Associated Aero Science Laboratories, Inc.

ROCKWELL MANUFACTURING CO.'s President Willard F. Rockwell, Jr., has been re-appointed to serve on the Advisory Council of the United States Committee for the United Nations. The committee in its eleventh year of activity, is a privately supported citizen's organization whose chairman is appointed annually by the President of the United States.

BUFFALO-ECLIPSE CORP. has transferred operations of Penberthy Manufacturing Co. Division from Detroit to recently expanded manufacturing facilities at Prophetstown, Ill. Personnel for production, supervisory, engineering and sales functions are included in the move.

GIRDLER CATALYSTS has named **Robert D. Evans** to head its technical sales and service office, 4007 Bellaire Blvd., Houston. He succeeds **Merle R. Likins,** who has joined the technical service staff at Girdler Catalysts' headquarters. Evans has a chemical engineering degree.

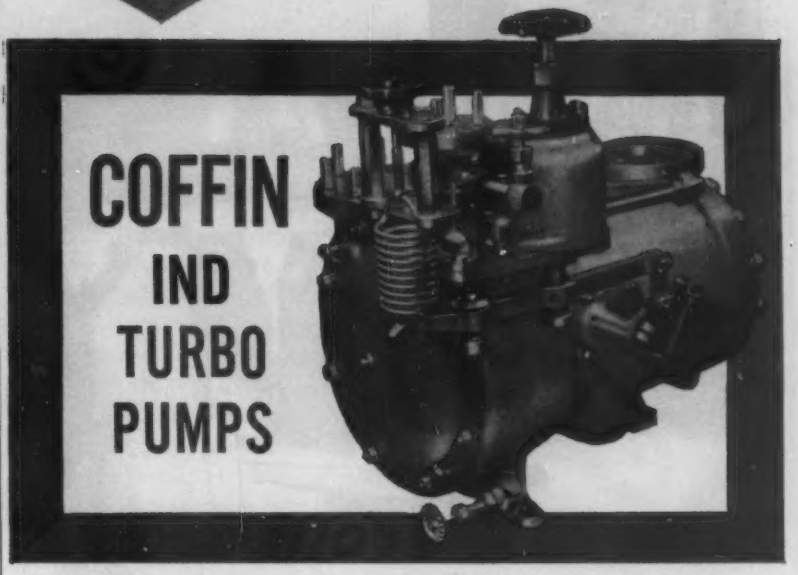
GRAVER TANK & MANUFACTURING CO. has named **James S. Taylor** and **Wayne Lutke** to new sales posts for oil and gas equipment sales. Taylor will operate out of Tulsa and Lutke was named district manager for oil and gas equipment sales, Midland, Texas.

GOULDS PUMPS, INC., Seneca Falls, N. Y., has opened a branch office in Shreveport. **T. G. Kelley,** with Goulds for 30 years, will manage the office at 1007 Petroleum Tower. He was formerly manager of the company's Houston branch office.

GENESYS CORP. has named **Lyne S. Trimble** assistant to the vice president, product development. Holder of an M.S. degree in physics from UCLA, he has been with Cinecolor, Inc., and Spazier Chemical Co.

ELECTRONIC ASSOCIATES, INC. has appointed **Robert L. Yeager** general sales manager, standard products. He will be responsible for the sale of the EAI line

Complete Pump, Turbine and Controls



PACKAGED — integral design of the IND Pump results in a compact, highly efficient unit which mounts impeller and turbine wheel on a short, rigid shaft. The unit is equipped with complete controls for constant or differential pressure regulation.

APPLICATIONS — compact and highly efficient, the Coffin type IND Steam Turbo Pump is designed for General Boiler Feed or any other pumping service where medium volume and high pressure is required.

SPECIFICATIONS-

Capacities	to 180 GPM —	Height 32"
Discharge Pressures	to 350 PSIG —	Width 25"
Liquid Temperatures	to 300°F —	Length 32"

For special installations these ratings may be exceeded.

Coffin Turbo Pump Co.
326 South Dean Street, Englewood, N. J.
Gentlemen: Please send me illustrated booklet further describing the Type "IND" Pump.

Name _____
Position _____
Company _____
Street _____
City _____ Zone ____ State _____

fmc
COFFIN TURBO PUMP CO.
FOOD MACHINERY AND CHEMICAL CORPORATION
326 South Dean Street • Englewood, New Jersey
Agents in all Principal Cities • Cable Address: COFCO

For more data on advertised products, use Readers' Service Cards, last page.

Looking For Cost Saving Ideas?

VISIT OVER 500 "CLASSROOMS" OF CHEMICAL PROGRESS

At the 27th Exposition of Chemical Industries you can attend over 500 "classes"—informative displays that show the newest advances in plant and process equipment, instruments and controls, material handling and packaging equipment, corrosion resistant materials *plus* special sections for chemicals and laboratory equipment and supplies.

This "course" will keep you abreast of new ideas that may help you cut costs, increase production and improve your product performance. Here you can see and learn more in a few days than is possible in any other manner.

Plan now to attend—and bring your key associates with you. Just one idea picked up here will make their visit worthwhile.

Write today for free advance registration and hotel information.

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27th EXPOSITION OF CHEMICAL INDUSTRIES

N. Y. COLISEUM · NOV. 30—DEC. 4.

Management: International Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Suppliers . . .

of general purpose analog computer systems, standard instruments, and data processing equipment. Yeager's organization will include the four regional sales offices in the United States, the European Regional Sales Office, Brussels, Belgium, and the manufacturers' representatives sales network in this country and Canada. He was formerly Eastern regional sales manager, a post which he held for the past three years. Before joining EAI, Yeager was an applications engineer at Industrial Nucleonics Corp., where he was supervisor in charge of company operations at Louisville, Ky.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has realigned sales administration activities involving control systems it produces. Consolidated into a newly-created Industrial Controls Division are the company's Control Devices and Machine Controls departments. **Ray R. West,** who formerly headed the Control Devices Section, has been named manager of the new division. With Honeywell 35 years in the field of industrial instrumentation, West has been transferred from the firm's Brown Instruments Division headquarters in Philadelphia to Honeywell's home office in Minneapolis.

West

CHEMETRON CORP.'s Girdler Construction Division and The Chemical and Industrial Corp., Cincinnati, will combine their activities and facilities. Chemical and Industrial will be the parent company and Girdler Construction its subsidiary. **H. H. Hamilton** will continue as chief executive officer of the parent company, and **W. Roberts Wood** will continue as head of Girdler Construction.

THE DOW CHEMICAL CO. has installed a high-speed electronic computer system to hasten the search for new rocket fuels, textile fibers, plastics and scores of other chemical products at Dow facilities, Midland, Mich. Dow plans installation of a new teletype system to link the computer center with other laboratories and work centers so that problems may be received and finished reports transmitted back over ordinary telephone lines.

HOOKER CHEMICAL CO. has established a new Buffalo District sales office to be occupied by the Eastern Chemical Division and the Durez Plastic Division. The newly created Buffalo sales district for the Eastern Chemical Division will include New York other than metropolitan New York City, Canadian areas near Lake Ontario, Western Pennsylvania, Ohio, West Virginia, and Kentucky. The Durez Plastics Division's new district will include New York other than metropolitan New York City, Eastern Canada, central and Western Pennsylvania, and Northern West Virginia. **Charles H. Fos-**

Fast help on corrosion control
–A big Texas natural gas plant required periodic analyses to determine whether MEA solution was breaking down in regeneration, forming corrosive salts. Samples were being sent out of state for analysis, "took forever" to get results. Enter Allied. Now tests are run in Dallas, results come back *fast*, help this plant prevent corrosion before it can start.

New plant start-up trouble quickly traced–Slug of distillate filled inlet scrubber, carried over to amine system. Aqueous amine solution thoroughly contaminated with hydrocarbon. Customer shut down plant, was going to dump entire charge. Allied specialists diagnosed trouble as too rich amine concentration, then suggested decanting solution into empty tanks, which saved half of charge.

Foaming in glycol plant–Customer wanted to know what caused it, how to stop it. Allied specialists flew to the site, deduced cause of the trouble in a matter of hours. Lab analysis confirmed their findings. In a recommendation just five typewritten lines long, they told customer how to solve the problem completely, economically.

USE GLYCOLS OR AMINES?

ALLIED technical service is ready–right now–to help you find straight answers to knotty problems

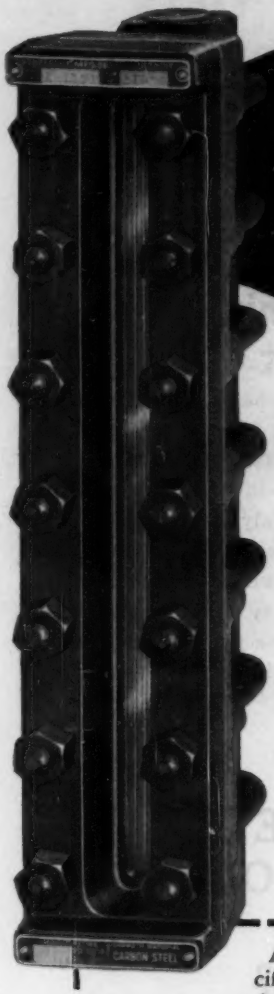
BASIC TO AMERICA'S PROGRESS

Allied Chemical

NITROGEN DIVISION
Dept. GA 5-21-2, 40 Rector Street, New York 6, N. Y.

2819

See for yourself why



PENBERTHY Liquid Level GAGES are your better buy

Without a doubt, Penberthy direct reading liquid level gages always give you a clear, accurate picture of the fluid level and/or color and density of the media.

They are available in a variety of materials and engineered designs to meet your specific requirements . . . corrosive conditions, pressures and temperatures.

REFLEX TYPE . . .
3 pressure groups to 3600 psig. Lengths to 12 ft. Liquid shows black.

TRANSPARENT TYPE . . .
4 pressure groups to 10,000 psig. Lengths to 12 ft. Shows color, density and media.

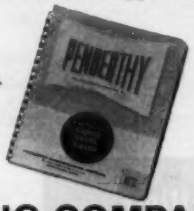
SPECIAL SERVICE TYPES . . .
High pressure, Frost-Proof, Heating Tube and Heating Chamber, Welding Pad, Large Chamber and Inclined Gages, Explosion-proof Illuminator.

All materials exceed ASTM, ASME and API specifications. Experienced design, exclusive features, selected drop-forged steel, heat-treating, accurate machining, Pyrex glass and accurate assembly assure long, trouble-free service.

Among other advantages . . .

- Perfect alignment of frame with glass and gasket minimizes leaks or glass breakage.
- Cover completely encloses sides and ends of glass and gasket preventing "blowouts."
- "Raised Face" makes cleaning and glass or gasket replacement easy — *without removing assembly from vessel.*
- Corrosion-resisting paint extends service life — maintains appearance.

Get the facts by writing for Catalog 36. Your inquiry will receive prompt personal attention.



PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
PROPHETSTOWN, ILLINOIS

Suppliers . . .

ter, Jr. has been appointed manager, Buffalo Sales District, for the Eastern Chemical Division, while **Harry H. Dent, Jr.,** continues in a similar post for Durez.

HAGAN CHEMICALS & CONTROLS, INC. has named **L. M. Faulkner** manager of sales and data processing, Controls Division, Pittsburgh. He will be responsible for the sale of electronic data processing, computing, and temperature monitoring equipment to the industrial field. A 1951 graduate of Bates College with a B.S. degree in physics, Faulkner has been with Hagan since 1953. He started as a service engineer, and in 1956 was promoted to the Pittsburgh district sales office, specializing in instruments and controls systems for the steel and public utility fields.

Faulkner

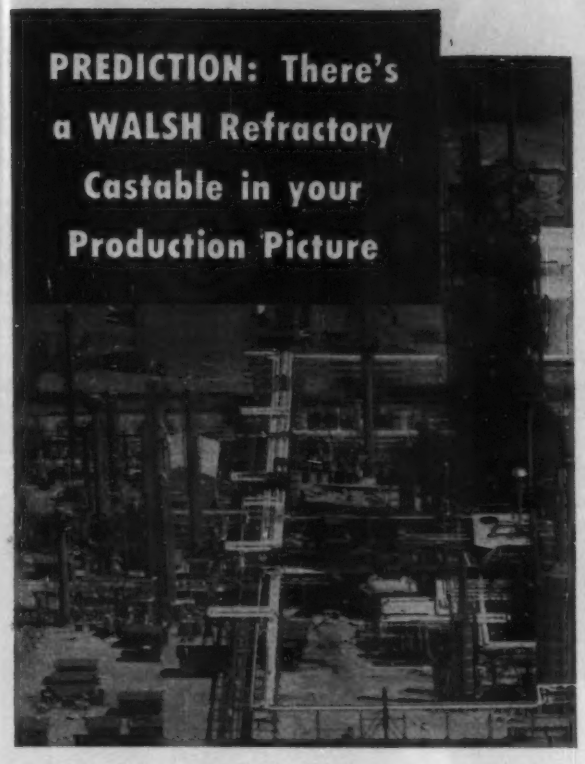
AMOCO CHEMICALS CORP. has named **Fred H. Moulton** district sales manager, Chicago. He replaces **R. E. Elliott,** recently appointed manager—industrial chemicals services. Moulton has been St. Louis sales representative since he joined the company about two years ago. He was formerly an industrial products salesman for Standard Oil Co. (Indiana). A graduate of Washington University, St. Louis, with a B.S. degree in chemical engineering, he is a member of ACS.

COOPER ALLOY CORP. has named **Gerald Lewis** director of product engineering. He joined Cooper Alloy in 1953 as sales manager of the Vanton Pump and Equipment Division. In his new position, Lewis will be responsible for product development, design and manufacture of the company's line of stainless steel castings, valves, fittings, plastic pumps, valves and fittings. Before joining Cooper Alloy, he was chief engineer of the J. J. Ashton Co., New York, from 1950-53 and as an industrial engineer with the Conmar Zipper Co., Newark, N. J.

ARMOUR INDUSTRIAL CHEMICAL CO. has named **M. E. Lewis** a vice president. He began with Armour in the Master Mechanic's Department at the Pittsburgh meat packing plant in 1934. He came to the Chicago general office in 1944 and was made manager of the Chemical Division's McCook, Ill., plant in 1951. Five years later he became general manager of the division.

CONSOLIDATED ELECTRODYNAMICS CORP.'s Analytical & Control Instrument Division has established a separate marketing organization. District sales and service offices have been opened in principal U.S. cities to provide direct liaison between the division and users of its analytical and control instruments. **Robert D. Enochs** has been named manager of the new marketing operation. He joined

PREDICTION: There's a WALSH Refractory Castable in your Production Picture



Assurance Of New Highs In Performance At Lower Cost

Whether your refractory castable practice calls for a two-component lining or consideration of a "one shot" system later on, you'll find the right Walsh product for your purpose. Modern as tomorrow, every Walsh Castable offers absolute homogeneity—the result of production control methods that insure the perfect union of all ingredients for efficient service throughout a longer life. The whole money-saving story is available from your nearest Walsh representative. Or, write us direct, today.

WALSH EXTRA STRENGTH H & B CASTABLE (Service Type) For highly abrasion-resistant, monolithic, working linings in catalytic regenerators, reactors, and other refinery equipment.

WALSH LITE WATE INSULATING CASTABLE NO. 50. Features high bulk density while retaining a low K factor. Recommended for backup use in two-component linings.

WALSH LITE WATE INSULATING CASTABLE NO. 70. Higher strength and a low K factor makes this insulating castable highly desirable for "one shot" linings.

All Walsh Castables are characterized by extreme "flowability", excellent nozzle compaction, lower rebound loss . . . plus greater strength, better bond . . . throughout the complete temperature range.

Send for New Illustrated Castable Bulletin

WALSH
REFRACTORIES CORPORATION
101 Ferry Street • St. Louis 7, Missouri
Specialists in Refractories of High Bulk Density and Low Porosity

RIDGID Thread Cutting Oils are available in convenient (4 ounce Nu-Clear only), 1 quart, 1 gallon, (2 gallon Nu-Clear only), 5 gallon, 30 gallon and 55 gallon containers.

Tests prove RIDGID® Thread Cutting Oil gives you better threads faster... lengthens die life, too!

Recently a distributor in Atlanta, Georgia investigated a complaint of "bad pipe". Test threads were made in all sizes. Torn threads resulted. Then RIDGID Nu-Clear Thread Cutting Oil was substituted for the oil being used. Perfect threads were obtained every time.

Here, then, is dramatic proof that you need a special purpose thread cutting oil . . . an oil that *cools, speeds metal removal, produces a smooth finish,* and *prevents chips from welding to your dies.*

No oil—in its pure state—will perform all these functions. That's why RIDGID Thread Cutting Oils are an exclusive, exactly formulated combination of oils, blended for easier, faster threading . . . longer die life. What's more, these special-purpose RIDGID oils are completely antiseptic . . . no danger of irritation or infection.

Make sure of good threads every time. Order RIDGID Thread Cutting Oil from your Supply House today. Tops for *all* metal cutting . . . you'll want an extra supply for your lathe, drill press and other metal cutting equipment.

RIDGID
The Ridge Tool Company • Elyria, Ohio, U.S.A.

Completes 46 Structures in 4 Months

at Petroleum Chemicals, Inc.

CB&I's *coordinated services* played a major role in construction of three new petrochemical plants recently placed on-stream by Petroleum Chemicals, Inc., at Lake Charles, Louisiana.

CB&I's assignment: Fabricate and erect 13 processing towers and 33 storage tanks for an expansion program that would—and did—put three plants in operation during a four-month period.

The new plants—ammonia, ethylene and ethylene oxide-glycol—have catapulted Petroleum Chemicals into a major petrochemicals producer, less than four years after its founding.

Companies on the move, such as Petroleum Chemicals, know they can depend on CB&I's *coordinated services* to meet exacting specifications and schedules. The reason: Expert, *one source* responsibility for engineering, fabrication and erection.

These are the benefits of CB&I's seven decades of *craftsmanship in steel*. Write our nearest office for the bulletin: *Development of the Oil Storage Tank*.

Propane is stored in these vertical blimps built by CB&I for Petroleum Chemicals. Each structure is 60 feet high, 12½ feet in diameter and has a 1,500-barrel storage capacity.

Chicago Bridge & Iron Company

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston • Kansas City
New Orleans • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • South Pasadena • Tulsa
Plants in Birmingham • Chicago • Houston • Salt Lake City • Greenville, Pa.
Torrance, Calif. • New Castle, Delaware

SUBSIDIARIES:
Horton Steel Works Limited, Toronto; Chicago Bridge & Iron Company Ltd., Caracas;
Chicago Bridge Limited, London; Chicago Bridge Construcoes Ltda., Rio de Janeiro

REPRESENTATIVES AND LICENSEES:
Australia, Cuba, England, France, Germany, Italy, Japan, Netherlands, Scotland

P-83CB

Suppliers . . .

CEC in 1951 as an installation engineer. He became a supervisor in instrument order service in 1953, assistant to the director of sales in 1956, manager of the company's district sales office in Dallas in 1958, and marketing manager for analytical and control instruments early in 1959. He is a graduate of the University of Colorado with a B.S. degree in electrical engineering and is a member of ISA.

THE COOPER-BESSEMER CORP. has named **Laurence B. Hume** assistant manager power engine sales. He will work directly out of Cooper-Bessemer's main office, Mount Vernon, Ohio. Hume will be responsible for the application and sale of gas, diesel and gas-diesel engines for use in all stationary power, marine and other mobile services. With Cooper-Bessemer since 1940, Hume had been with the Washington, D. C., sales office.

Hume

VULCAN MANUFACTURING CO. has commenced full-scale operations in its new plant and offices, Woodlawn, Ohio. Representing an investment of about $1 million, this move provides Vulcan with space and facilities required to expand and diversify operations. With the new plant, Vulcan can fabricate chemical process equipment, distillation towers, heat exchangers, condensers, and all types of pressure vessels—up to 13 feet in diameter, 100 feet long and weighing 60 tons.

THE BLAKE EQUIPMENT CORP. has been named exclusive sales representative in Southern New York and Northern New Jersey for Daniel Orifice Fitting Co., Houston. The firm is located in Englewood, N. J., 409 Grand Ave. Officers are **David M. Breslauer,** president; **Warren S. Jones,** vice president; **Lamar R. Speer,** vice president; and **Theodore Donde,** secretary treasurer and general manager.

NALCO CHEMICAL CO. has named **David G. Braithwaite** executive vice president in charge of manufacturing, research and development. He formerly headed Nalco's Catalyst Division and most recently had been in charge of the company's program of expansion. With Nalco since 1946, he was named a vice president in 1954 and was elected to the board of directors in 1957. He holds a Ph.D. degree in physical chemistry from Northwestern University.

BJORKSTEN RESEARCH LABORATORIES has named **Dr. L. F. Yntema** consultant on research and development of foamed metals. Formerly vice president, director of research of Fansteel Metallurgical Corp. and senior metallurgist at Stanford Research Institute, Dr. Yntema's background is in the fields of inorganic

Why instant condensate drainage is important in refinery applications

- In refinery applications, it's important that all outdoor steam traps discharge air and condensate as soon as it reaches the trap. Outdoor traps must also be capable of draining the steam units and pipelines dry, as well as the trap itself, when steam is shut off to prevent damage from freezing.

Anderson Quik-Flex Steam Traps are designed for this special outdoor refinery use. Companion to well-known Super-Silvertop inverted bucket traps, they feature a trigger-action valve that responds instantly. Guaranteed against freezing for two years, they are the ideal refinery trap.

For complete specifications on Anderson Quik-Flex Steam Traps, mail the coupon today.

A TRAP FOR EVERY PURPOSE

THE V. D. ANDERSON COMPANY
division of International Basic Economy Corporation
1953 West 96th Street • Cleveland 2, Ohio

Please send without obligation your 36-page steam trap engineering catalog, "How to Select Steam Traps and Other Fluid Specialties".

Name_____ Title_____
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ANDERSON QUIK-FLEX

For more data on advertised products, use Readers' Service Cards, last page.

One slip can cost more than USS Multigrip...

What percentage of occupational accidents is caused by falls? In one state, falls were responsible for 17 per cent of all injuries, 33 per cent of the days lost and 23 per cent of the direct cost. (From National Safety News, February, 1959.) Falls ranked No. 1 as the cause of most accidents.

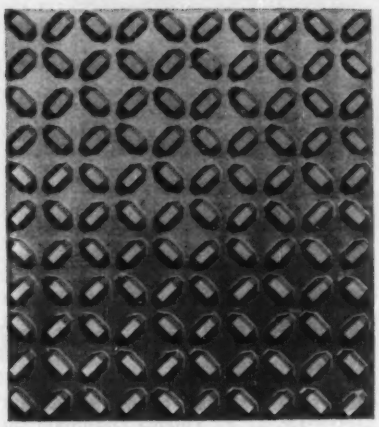
Fortunately, you can do something to prevent falls by installing USS Multigrip. Multigrip floor plate provides safe traction in any direction. It is studded with little cleats that are flat on top and do not catch the shoe.

For dangerous locations such as machine shops, loading platforms, stair treads and catwalks, USS Multigrip supplies safety plus.

Saves money, too! Where floors take a pounding from heavy traffic, Multigrip will stand for years under constant use. There's little or no maintenance.

On your next inspection trip, search out the hazardous locations—and make them safe with USS Multigrip.

USS is a registered trademark



Sold by leading distributors from coast to coast.

United States Steel Corporation—Pittsburgh
Tennessee Coal & Iron—Fairfield, Alabama
Columbia-Geneva Steel—San Francisco
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

Aloyco Valves on 26-year duty in hot acid system

Still going strong in the sulphite pulp mill of Eastern Fine Paper and Pulp Division, Standard Packaging Corp., at South Brewer, Maine, is the Aloyco Stainless Steel "Y" valve, above.

This, and other Aloyco Valves were purchased in 1933 when the hot acid system was installed here. They have been in continuous use ever since.

Long trouble free service is the reason so many U. S. plants are turning to stainless steel and high alloy valves... even for mild corrosive service.

Only one company has specialized in corrosion-resistant valves exclusively for 30 years: Alloy Steel Products Co. Call us in on your next valve job. Write us at 1303 West Elizabeth Ave. 9.7

Longer Lasting ALOYCO VALVES

ALLOY STEEL PRODUCTS COMPANY
Linden, New Jersey

Suppliers . . .

and electrochemistry, rare earths and refractory metals.

Dr. Stanley A. Dunn, formerly with Rhodia, Inc., has also joined the laboratory to supervise projects involving improved materials using high temperature and high pressure techniques.

Other recent additions to the expanding technical staff of Bjorksten Laboratories, Madison, Wis., are **Edward J. Rock, Jr., Vernon K. Rising, Gordon Jensen, Arnold Flagel, Darrell Lien, Melvin Blahnik** and **Arthur Sincere. Joel N. Lipscomb** and **Miss Catherine J. McGough** recently joined the staff of Bjorksten Texas Research Co., Houston.

THE PATTERSON FOUNDRY AND MACHINE CO. has named **John N. Lewis** manager of the Detroit District sales office. Prior to joining Patterson, he was with Boydell Bros. Co., Detroit. He replaces **A. T. Jacobson,** who recently was named general sales manager of the company. A former president of the Detroit Paint and Varnish Production Club, Lewis is a graduate chemical engineer. He attended the University of Detroit and Wayne State University.

Lewis

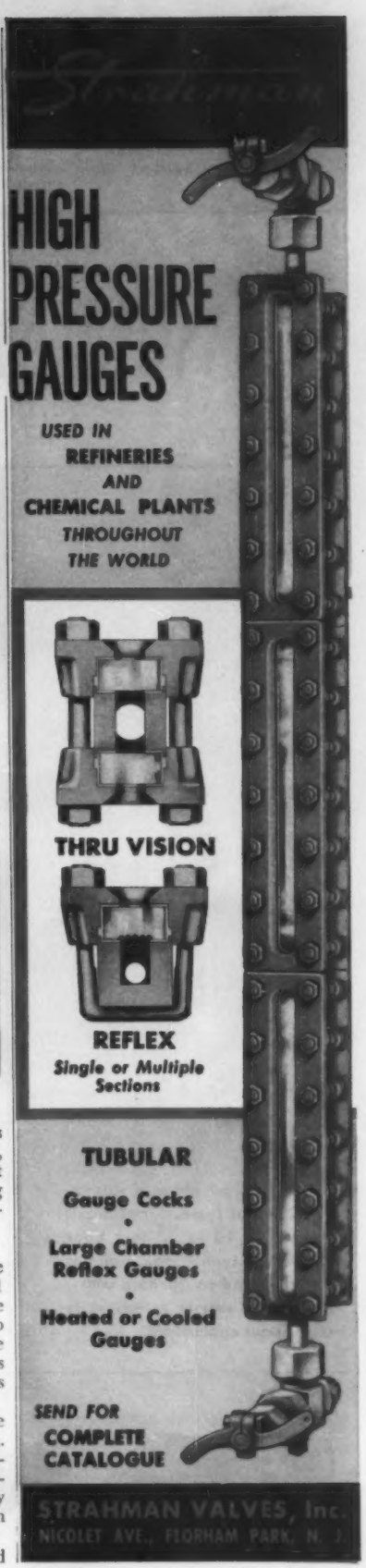
ROCKWELL MANUFACTURING CO.'s Petroleum and Industrial Meter Division has named **Nelson E. Davenport** export sales manager, meter and valve products. His main responsibility will be to manage Rockwell's P & I business, and the sale of Rockwell meter and valve products in the Canadian market. A licensed professional engineer, Davenport joined Rockwell as a sales engineer in 1950, moved to Pittsburgh as assistant product manager, gas products, in 1935 and assumed his most recent position in January 1957. Before joining Rockwell he was a process design engineer with Taylor Refining Co.

Davenport

THE TORRINGTON CO. has assigned **George W. Ging** to manage its office at 1731 First Ave., South, Seattle. He joined the Torrington sales staff in 1956 after two years service with the Army. A graduate of Kansas State College, he holds degrees in mechanical engineering and business administration.

Douglas B. McLaren will direct the office at 1607 Jefferson Ave., Houston. He is a graduate of Worcester Polytechnic Institute, became affiliated with Torrington in 1954, resigned for military service and rejoined the sales staff in 1958.

Leonard C. Larsen has been assigned



For more data on advertised products, use Readers' Service Cards, last page.

Glenn L. Martin Airport

Crucible Steel Co. of America

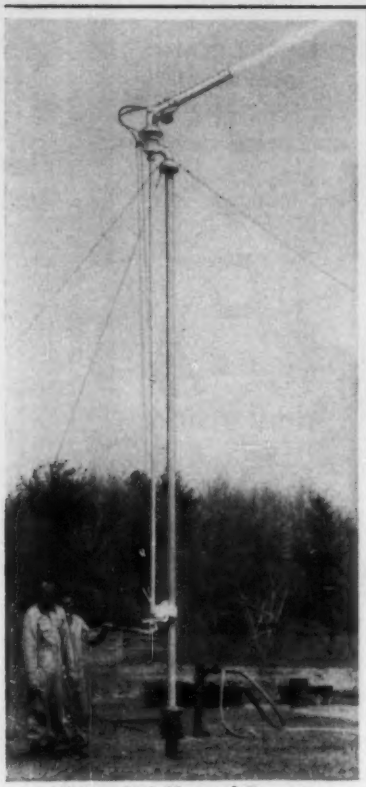
McDonnell Aircraft

Seattle-Tacoma Airport

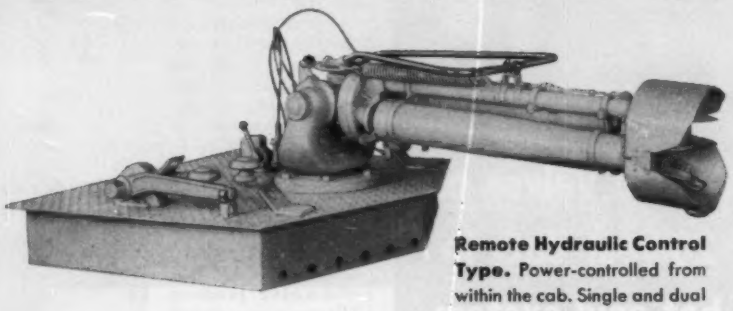
U. S. Coast Guard

Most Complete Line of

ALL ROCKWOOD TURRETS DISCHARGE
FogFOAM • SOLID FOAM STREAM
WaterFOG • SOLID WATER STREAM



Extended Manual Remote Control Type. Turret nozzles extend 10 to 20 feet above remote control station on deck or ground on standard units... greater remote extensions for special applications.



Remote Hydraulic Control Type. Power-controlled from within the cab. Single and dual models. Widely used on air crash rescue fire-fighting trucks.

Direct Manual Control Type. Gives fire fighters "out-in-the-open" control from cab roof!

Washington, D. C. National Airport

U. S. Air Force Type 0-12

Theodore Francis Greene Airport

Douglas Aircraft Co.

For more data on advertised products, use Readers' Service Cards, last page.

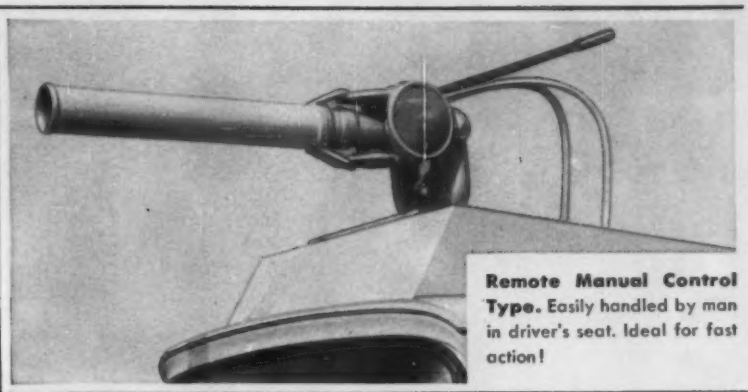
Socony Mobil Refinery, Augusta, Kan. | Fairchild Aircraft Corp. | Cuba, N. Y. Fire Department | Royal Canadian Navy | Dayton, Ohio, Airport

Specialty Turrets on the Market!

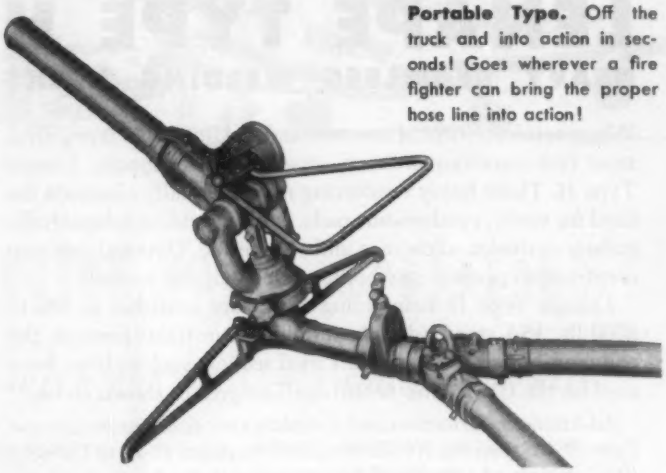
On the truck or on the ground, fire fighters can hit fires *harder* using ROCKWOOD Turrets! At airports and refineries . . . in municipalities and throughout industry . . . these advanced-design fire-fighting aids are constantly proving their ability to extinguish fires faster.

The reason is simple. ROCKWOOD Turrets provide plenty of both volume *and* versatility. They're designed to fight fires four ways: With FogFOAM . . . Solid FOAM Stream . . . WaterFOG . . . Solid Water Stream. What's more, all are easily adjustable on the fire line to meet changing fire conditions.

Produced by the world's largest manufacturer of specialty Fire-Fighting Turrets, ROCKWOOD Turrets are designed to give fire fighters an extra edge of efficiency on *most* types of fires. Make sure your department has the best tools to work with. Get full details on the complete line of fire-fighting products. Mail coupon now.



Remote Manual Control Type. Easily handled by man in driver's seat. Ideal for fast action!



Portable Type. Off the truck and into action in seconds! Goes wherever a fire fighter can bring the proper hose line into action!

ROCKWOOD SPRINKLER COMPANY

Engineers Water... to Cut Fire Losses

ROCKWOOD SPRINKLER COMPANY
A Division of the Gamewell Company
Portable Fire Protection Division
505 Harlow Street, Worcester 5, Massachusetts

Please send me your illustrated booklet on Rockwood Fire-Fighting Products

Name.....*Title*.....

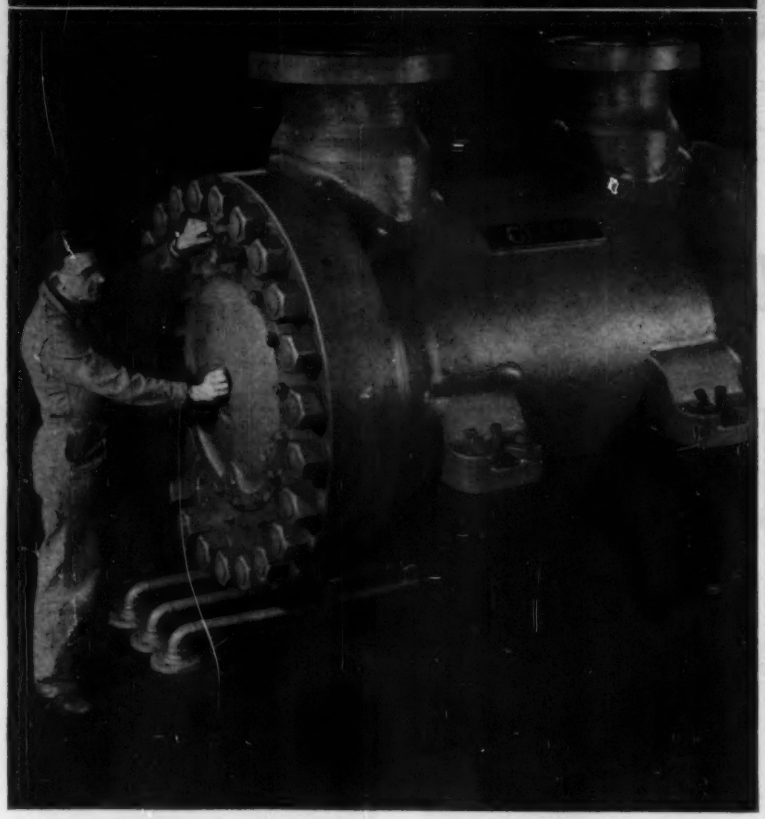
Company.....

Street.....

City.....*Zone*....*State*.....

For more data on advertised products, use Readers' Service Cards, last page.

BUILT-IN REINFORCEMENT



LENAPE TYPE H

HEAVY SEAMLESS WELDING NECKS

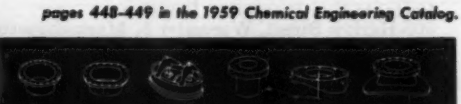
Where reinforcement of conventional welding necks is required, most cost-conscious pressure vessel designers specify Lenape Type H. These heavy reinforcing necks normally eliminate the need for costly, cumbersome pads, while providing substantially greater corrosion allowance and service life. Optional nut stop construction permits easy bolting using only one wrench.

Lenape Type H Reinforcing Necks are available in 300 to 2500 lb. ASA standards. For installation in tight quarters, the ends can be formed with a 2:1 oval section, such as have been used on the Clark Bros. centrifugal compressor shown above.

Additional information and complete specifications on Lenape Type H Reinforcing Necks are given on pages 16-18 in Catalog 10-53, a copy of which will be sent upon request.

LENAPE PRESSURE VESSEL CONNECTIONS

See our standard line of pressure vessel connections on pages 448-449 in the 1959 Chemical Engineering Catalog.



LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 106 WEST CHESTER, PA.
RED MAN PRODUCTS

Suppliers . . .

as assistant to **E. G. Rowlett** in the office at 4433 Crenshaw Blvd., Los Angeles. Larsen has been with Torrington since 1956.

Gordon Duncan is joining the staff of the Torrington office at 925 Millwood Road, Toronto. A graduate of the University of Toronto and of Ryerson Institute of Technology, he has been in training at the Torrington and South Bend, Ind., plants.

Haltom

Flowers

C-B- SOUTHERN, INC. has named **Harry L. Jackson,** former technical service manager and assistant chief engineer at the Union Tank Division of Butler Manufacturing Co., a development engineer. He is a graduate of Rice Institute, with a degree in mechanical engineering.

Jackson

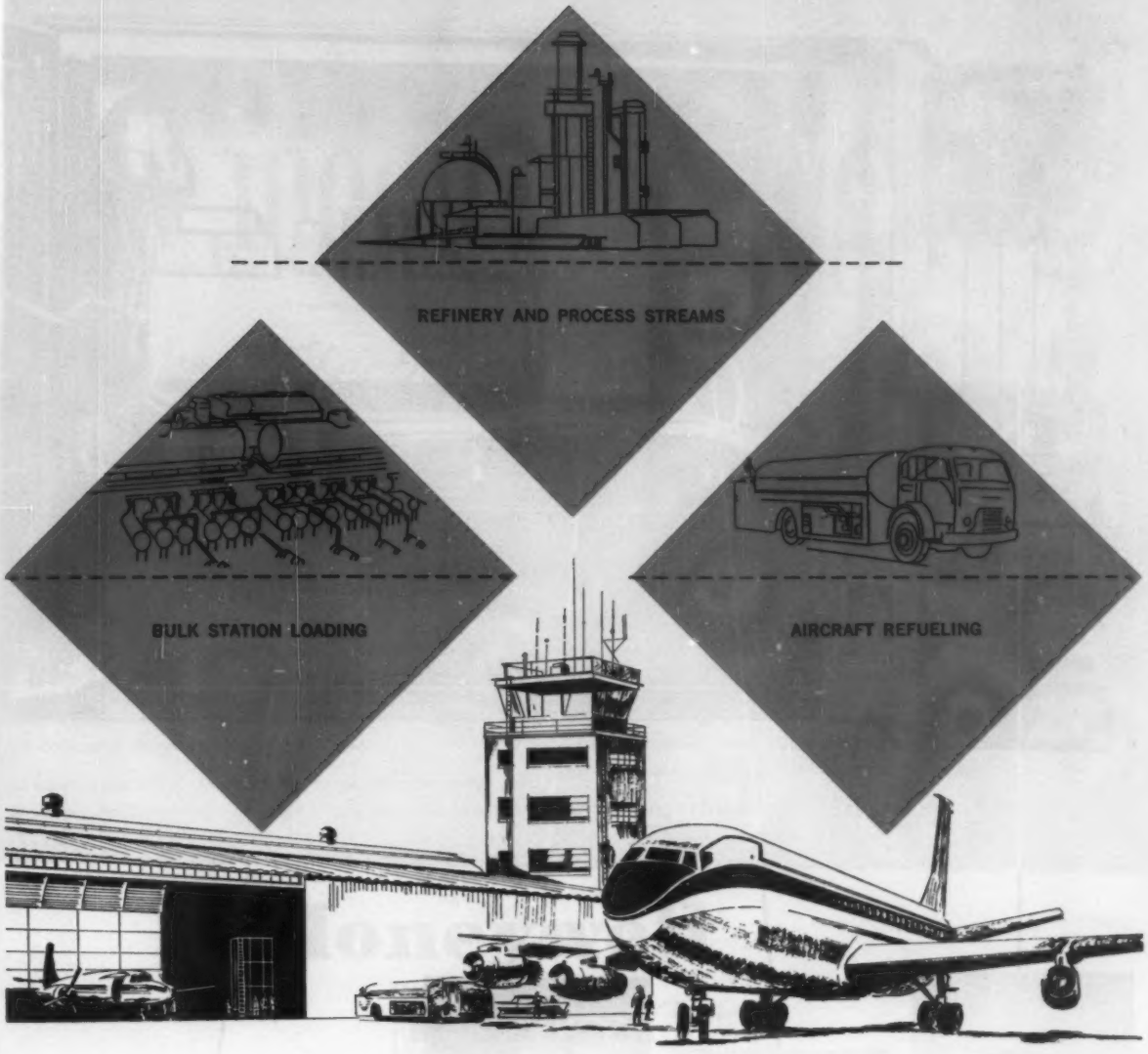
Richard L. Flowers and **George H. Haltom** are new members of the CB/S sales engineering staff. Flowers was formerly division equipment engineer, Phillips Petroleum Co., while Haltom has been manager of machinery sales for the Houston Oilfield Material Co. for the past 14 years.

CONSOLIDATED SYSTEMS CORP. has received a $445,000 contract from the Bureau of Yards and Docks, Eighth Naval District, for construction of a data processing system at the Naval Ordnance Aerophysics Laboratory, Daingerfield, Texas.

THE HARCO CORP. has named **F. A. Redman** special projects engineer, Cathodic Protection Division. He will be responsible for standardizing Harco's manufactured products, production methods and installation techniques. Before joining Harco, Redman was an instrument engineer with McDowell Co., Cleveland. His background includes experience in design and engineering with Diamond Alkali, Allied Chemical & Dye, McGean Chemical and Babcock & Wilcox companies.

GENERAL CONTROLS CO. plans to step up manufacturing and sales of its entire precision potentiometer line through duplicate production in both the United States and England. Potentiometers will continue to be produced in the company's

For more data on advertised products, use Readers' Service Cards, last page.



CONVERT EXCELSIOR PACK SEPARATORS

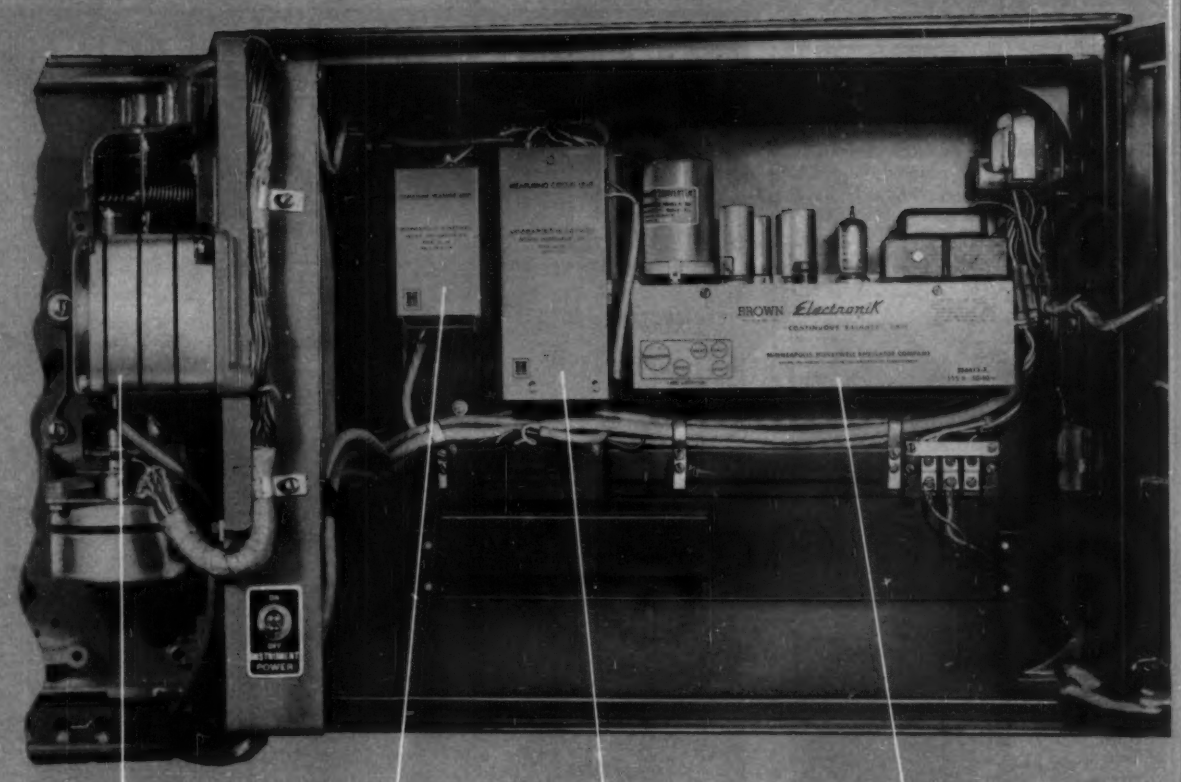
fast, economically with WARNER LEWIS *conversion kits*

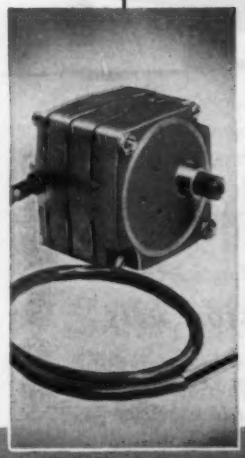
This new kit converts your existing excelsior packed separators into high efficiency filter/separators for removal of fine solids and emulsified water in finished petroleum products. In today's exacting requirements in refinery processing, bulk station loading and jet aircraft fueling, it is most important to have clean, dry products. Since Warner Lewis Company is the original manufacturer of excelsior-type separators, our complete files insure correct fit of conversion kit and maximum efficiency of operation at lowest possible cost. Write us today for complete information on your requirements.

WARNER LEWIS COMPANY
BOX 3096 • TULSA, OKLAHOMA

DIVISION OF FRAM CORPORATION

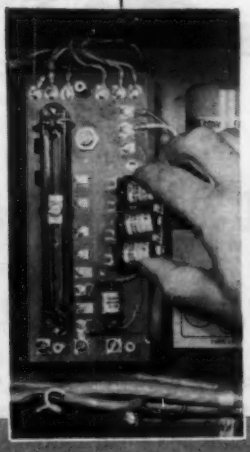
For more data on advertised products, use Readers' Service Cards, last page.



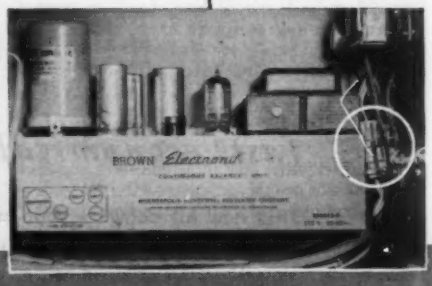


Servo Motor has sectional housing, leakproof oil wick, printed circuits for simplified servicing. Any major part can be replaced in 2 minutes.

Constant Voltage Module—Uses Zener diodes and an ambient temperature compensator to replace standardizing mechanism.



Measuring Circuit Module—Contains easily-changed range spool panels and vernier adjustment. Range is changed simply by replacing screw-clip panels of fixed resistors.



Amplifier Module—Quick-connect design permits fast, easy removal for servicing and replacement. Circle shows quick connect plug.

THESE FOUR NEW FEATURES ARE STANDARD WITH ALL *ElectroniK* POTENTIOMETERS

New modular design...

makes *ElectroniK* potentiometers easier to use and maintain

Now, four great new features add new operating and servicing ease to all *ElectroniK* circular and strip chart potentiometers.

- **New servo and chart drive motors are sectionalized so that any major part can be replaced in two minutes.**
- **A new constant voltage unit replaces batteries, standard cells and standardizing mechanisms.**
- **A new measuring circuit, with quick-change range spools, simplifies range changing and reduces stray pickup.**
- **A quick-connect feature lets you remove the amplifier for service and replace it quickly.**

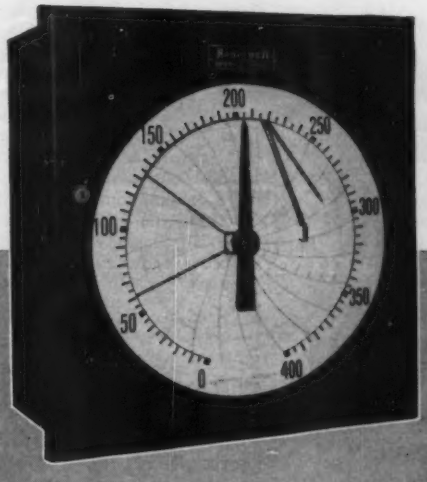
Now, modular design is combined with the traditional precision of *ElectroniK* potentiometers, to give you a greater value than ever in accurate, dependable measurement and control.

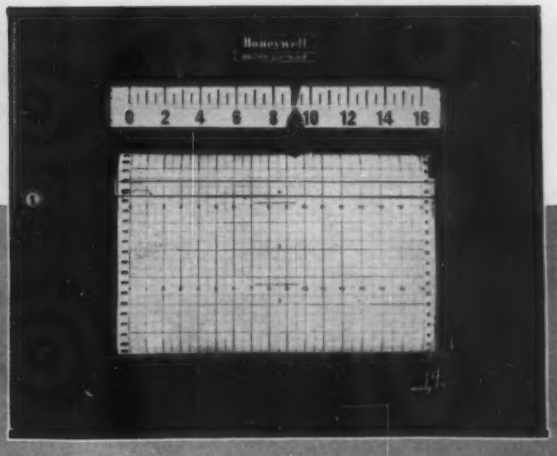
For full details, call your nearby Honeywell field engineer today. He's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

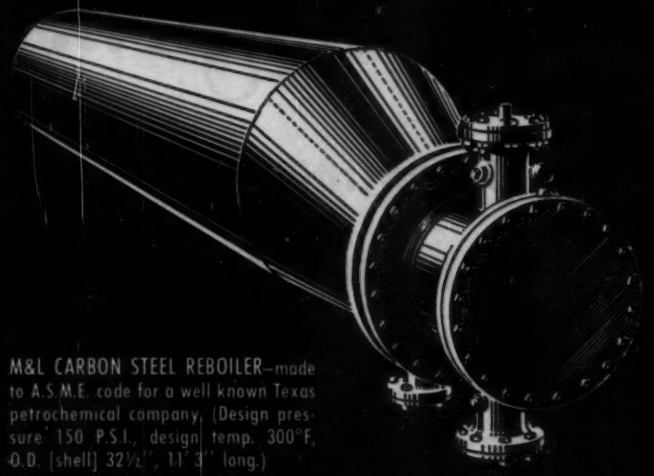
Honeywell

H HONEYWELL *First in Control*





MANNING & LEWIS



M&L CARBON STEEL REBOILER—made to A.S.M.E. code for a well known Texas petrochemical company. (Design pressure 150 P.S.I., design temp. 300°F, O.D. [shell] 32½", 11' 3" long.)

Today's rapid strides in the technology of processing plant operation make it essential for a manufacturer of equipment to be "staffed up" with people who have had extensive training and experience. More than half our staff have spent a major part of their working life in this one field and have played a major role in the design and fabrication of many types of processing equipment. They know the limitations and workability of all metals and how to get maximum service from each. This accumulated knowledge of base materials and our extensive experience in design and fabrication means practical, trouble-free equipment at the lowest possible cost.

It is impossible, in a field requiring such wide diversification, to illustrate, or even list, all the products we have been called upon to supply. The reboiler above is simply one among thousands.

Call on us the next time you need equipment. We are fully qualified to design and fabricate to all codes.

M&L MANNING & LEWIS

ENGINEERING COMPANY

28-42 Ogden Street, Newark, New Jersey

Dept. C

DESIGNERS & MANUFACTURERS OF QUALITY HEAT EXCHANGE EQUIPMENT

Suppliers . . .

Electronic Controls Division plant, Burbank, Calif., and the line will be continually improved and expanded in the United States. They will also be manufactured in the new company subsidiary, General Controls Ltd., Essex, England. The British factory was formerly Wirepots, Ltd., a manufacturer of potentiometers and dials.

ROCKWELL MANUFACTURING CO. has named **Brigadier General Joseph M. Colby** deputy commanding general, U.S. Army Ordnance Missile Command, Redstone Arsenal, Ala., vice president of engineering. The appointment was effective October 1, General Colby's retirement date. A graduate of the U.S. Military Academy, also has a M.S. degree from Massachusetts Institute of Technology, and is a graduate of the Army Industrial College and the Command and General Staff School. During a 34-year Army career, General Colby conceived, developed and patented many devices covering transverse transmissions, air-cooled engines, torsion bar suspensions, gun mounts, vision devices, and other mechanisms used in U.S. Army tanks.

Colby

ALUMINUM CO. OF AMERICA has named **Kirk Usher** manager of tubular product sales. A member of Alcoa's sales force in Newark, N. J., since 1946, he currently has headquarters in Pittsburgh, and is responsible for the sale of extruded and drawn pipe and tubing. Usher attended colgate University. He began his career with Alcoa in 1946, as a sales apprentice in the Newark office.

MINNEAPOLIS-HONEYWELL REGULATOR CO. is building a second large-scale electronic data acquisition system for use in high-speed processing of rocket engine test information. It will be installed at the Bacchus, Utah, rocket propellant plant of Hercules Powder Co., which is developing a third-stage engine for the solid-fuel Minuteman, an Air Force "second generation" intercontinental ballistic missile. The Honeywell system is being built at the company's Beltsville, Md., Division where another system, for installation at the Navy-owned Alleghany Ballistics Laboratory at Pinto, W. Va., is nearing completion.

A. Y. McDONALD MANUFACTURING CO. has named **William A. Headlee** manager of the Kansas City, Mo., Branch. He was formerly branch manager of the Wholesale Division of Rogers Bros. Seed Co.

MALONEY-CRAWFORD TANK AND MANUFACTURING CO. has named **Glenn L. Rader** vice president and special sales representative, Tulsa. His transfer and appointment is designed to strengthen

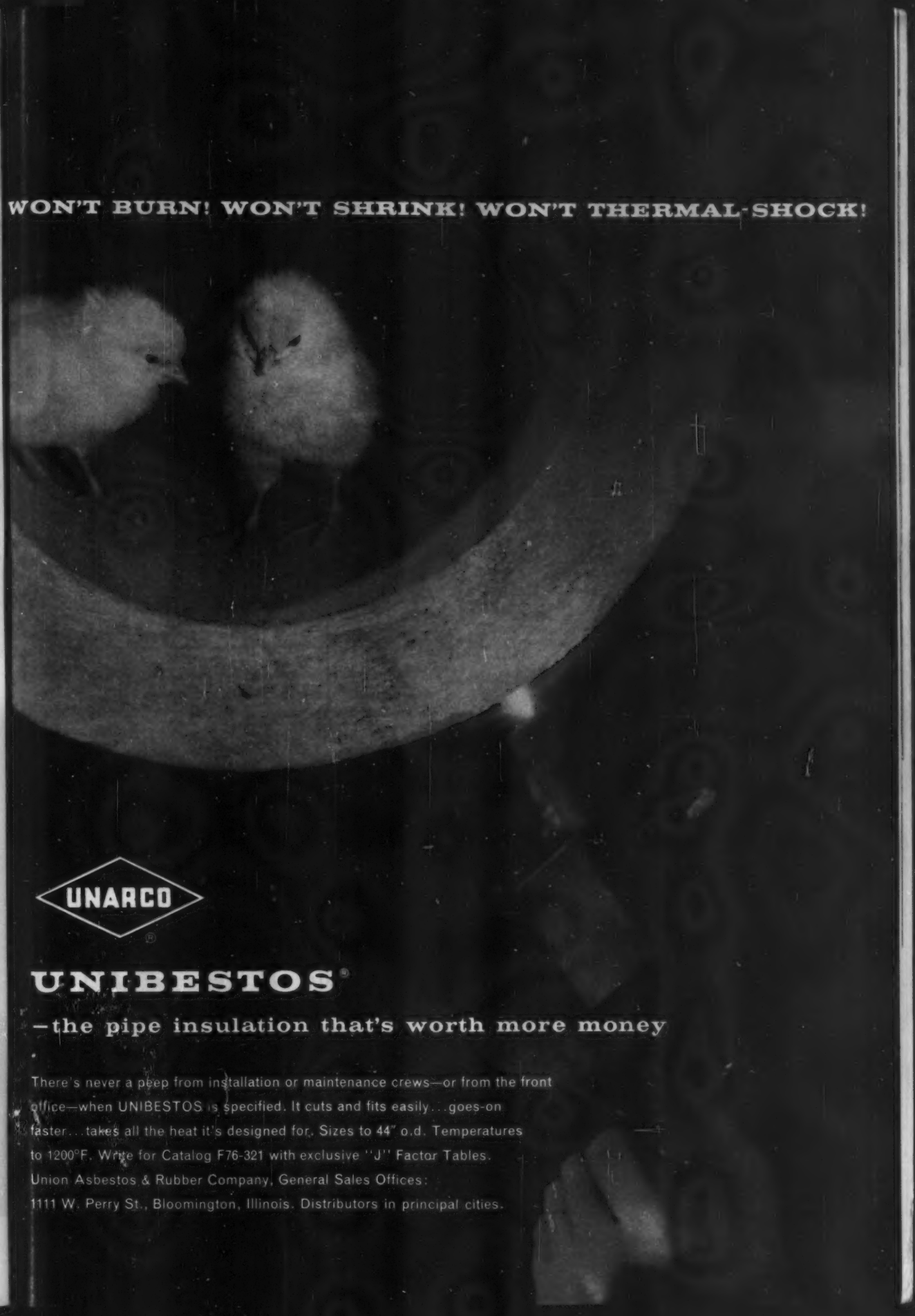

WON'T BURN! WON'T SHRINK! WON'T THERMAL-SHOCK!
UNARCO
UNIBESTOS®
—the pipe insulation that's worth more money
There's never a peep from installation or maintenance crews—or from the front office—when UNIBESTOS is specified. It cuts and fits easily...goes-on faster...takes all the heat it's designed for. Sizes to 44" o.d. Temperatures to 1200°F. Write for Catalog F76-321 with exclusive "J" Factor Tables.
Union Asbestos & Rubber Company, General Sales Offices:
1111 W. Perry St., Bloomington, Illinois. Distributors in principal cities.

Fig. 2187
Iron Body, Bronze Mounted
O.S. & Y.
Gate Valve
bevel gear.

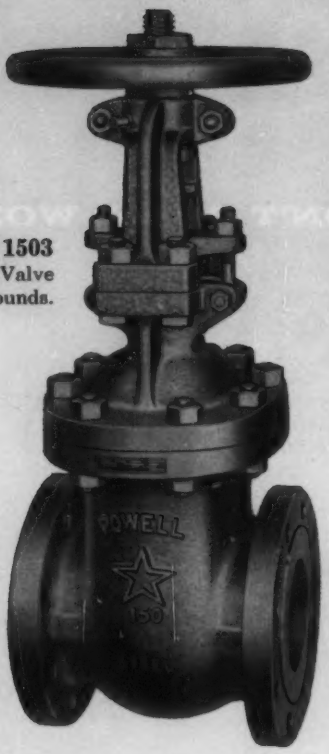


Fig. 1503
Steel Gate Valve
for 150 pounds.

POWELL-VALVES FOR

Powell was making valves when the first oil well was drilled in the United States over a century ago. So Powell Valves were ready to serve the oil industry from the very first day of its existence. And now for a century Powell has supplied the vital valves to the round-the-globe petroleum lifeline.

Powell offers valves in the greatest variety of sizes,

Fig. 9061
Cast Steel Swing Check Valve
for 900 Pounds.

Fig. 2200
Semi-Steel Lubricated
Plug Valve.
175 Pound W.O.G.

Fig. 6003
Steel Gate Valve
for 600 pounds.

Fig. 1583
Large Ductile
Iron Gate Valve
for 150 W.S.P.

THE OIL INDUSTRY

designs, pressures, and metals to cover every valve need in oil refineries, petrochemical installations, and storage facilities everywhere in the free world.

Powell engineers and metallurgists will gladly make a special analysis of your requirements and submit recommendations to fill all your valve needs. Write directly to us . . . or consult your local Powell distributor.

POWELL

world's largest family of valves
The Wm. Powell Company, Cincinnati 22, Ohio
Dependable Valves Since 1846

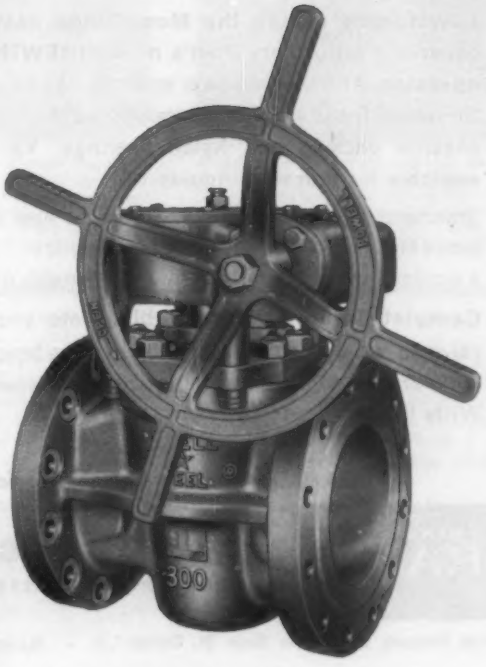


Fig. 3059G
300 Pound Steel Lubricated
Plug Valve. Gear Operated.

See us at booth 133, 27th Exposition of Chemical Industries, New York City . . . November 30 - December 4.

For more data on advertised products, use Readers' Service Cards, last page.

NEW! Monoflange valve is guaranteed drop-tight at 150#

The Henry Pratt Monoflange MK II is a top quality butterfly valve that fits between the pipe flanges of a fluid or gas line. **It saves weight, space and labor** because it eliminates a pair of flanges and requires only one bolting operation. **It eliminates gaskets** because the faces as well as the inside of the valve body are covered with rubber permanently bonded to the metal.

Low torque makes the Monoflange easy to operate, especially with Henry Pratt's **new SIDEWINDER manual operator.** Any type of power operator can be used if desired. Structural features include streamlined disc, one piece shaft, chevron packing and Nylon bearings. Various materials available for corrosive liquids.

Standardized and mass produced, this new valve offers famous Henry Pratt quality at a new low price . . . you can't find a similar valve that offers so much in quality or performance.

Complete information available. Water and gas flow data, valve sizing, operator selection in 26 page brochure. An ideal tool for the engineer working with and specifying valves. Write for Bulletin 10 AB

Creative Engineering for Fluid Systems

HENRY PRATT®

Monoflange MK-II
RUBBER SEAT BUTTERFLY VALVE

Henry Pratt Company, 319 W. Van Buren St., Chicago 7, Ill. • Representatives in principal cities

Suppliers . . .

the expanded Maloney-Crawford organization in the Gulf Coast area.

Rader has been vice president and sales manager since 1956, and before that was vice president and division manager for 11 years. He was one of the organizers of Crawford Tank and Supply Co., and served as division manager at Houston from 1943-45. Before joining Maloney-Crawford, Rader was with Parkersburg Rig and Reel Co.

E. I. DU PONT DE NEMOURS & CO.'s Petroleum Chemicals Division has named **J. Morgan Ogilvie,** for the past year sales service representative, Chicago District, sales promotion coordinator in the division's Eastern Region. He replaces **Robert A. Paulsen** who moves to the Gulf Coast Regional Office, Houston.

Charles S. Russ has moved from the Gulf Coast Region, where he has been account manager and sales promotion coordinator, to the Petroleum Chemicals Division's headquarters, Wilmington, Del., as technical assistant, Sales Promotion Section.

James M. Poole will be transferred from the latter section to the division's Eastern Region as an account manager.

Raymond A. Blank will move to the division's Mid-Continent Region, Tulsa, as an account manager. Since early 1957, he has been an account manager in the Philadelphia District of the division's Eastern Region.

ALLIED CHEMICAL CORP.'s Solvay Process Division has named **Jerome L. Hochenedel** assistant manager, Houston Branch. **E. Kenneth Leins** moves from the Division's Technical Service Department, Syracuse, N. Y., to its New Orleans Sales Branch. He has been assigned to the Baton Rouge sales territory.

Hochenedel received a degree in chemical engineering from Louisiana State University. He joined Solvay in 1951 and since then has been a salesman covering the Baton Rouge territory. Leins graduated from Cornell University with a B.S. degree in chemical engineering. A Solvay employe for 10 years, he has had plant experience and field and laboratory background as a member of the technical service staff.

MALONEY-CRAWFORD TANK AND MANUFACTURING CO. has realigned key personnel in its Sales Division. All those affected are personnel on the staff of Maloney-Crawford or Union Tank Co., which recently was acquired by the Tulsa firm and whose organization is being assimilated by Maloney-Crawford.

Ed C. Kopp, formerly a division manager for M-C, has been named vice president with headquarters in Fort Worth.

George W. Smith, formerly regional manager for Union in Dallas, has been appointed division sales manager of the new organization with offices in Houston.

Clint B. Warren, former M-C sales manager at Houston, has been named division sales engineer.

Thomas Q. Mayes, former M-C assist-

DU PONT *Petroleum Chemicals* NEWS

Number 99 in a Series of Bulletins for the Petroleum Industry

NOVEMBER-DECEMBER 1959

New Du Pont Cartoon Movie Wins Friends for Refiners

MANAGER, CLEVELAND DISTRICT OFFICE

JOSEPH G. EVANS was recently appointed manager of the Cleveland district office of the Petroleum Chemicals Division.

Mr. Evans, a native of Franklin, Pennsylvania, was graduated from Texas A&M College with a bachelor of science degree in mechanical engineering and joined the Petroleum Chemicals Division of the Du Pont Company in December of 1951 as a sales service representative in Tulsa, Oklahoma. He was formerly associated with the Standard Stoker Company of Erie, Pennsylvania, as a development engineer, and later formed his own company handling specialized industrial and automotive lubricants.

Mr. Evans spent five years as an officer aboard submarines and destroyers in the Pacific area during World War II.

Previous to his present assignment, Mr. Evans managed the San Francisco district office of the Petroleum Chemicals Division. He has had considerable experience with refinery problems especially in connection with the handling of tetraethyl lead and other additives. He is a member of the American Society of Mechanical Engineers and the API.

Remember Aladdin's genie? He had nothing on the mighty-muscled genie who waits to serve mankind today in each gallon of gasoline. Aladdin had only to rub his lamp. Today's motorist has only to say "Fill 'er up!"

For thousands of years "Gasoline" remained hidden underground, waiting for that day in 1859 when "he" would be released. Even then the need for his strength was slow to develop. In 1898 there were only 800 cars on the road. Today there are more than 70 million cars and trucks.

To give gasoline even stronger muscles for the big jobs it must do, it is torn apart and put together again by reforming, polymerization and alkylation. And, in spite of taxes of around 9¢ on every gallon, it is still one of our biggest bargains.

Today, gasoline not only keeps car wheels turning, but also supplies the power for braking, for steering, for lighting the road, for blowing the horn, for radio music and news, for air conditioning . . . even for lighting a cigarette and activating power seats and power windows.

"Gasoline is one of today's biggest bargains" is the message left with the viewers of Du Pont's newest cartoon movie, "Fill 'Er Up!" Subtle, yet hard-hitting, it makes the point to your audience simply and unmistakably. It does an effective public relations job for you when shown to employees or local school, social and civic groups.

The story of oil progress and, by implication, your part in it is told entertainingly. As important as the story it tells, though, is the fact that it leaves your audiences with a warm and friendly feeling toward you as the sponsor as well as toward the whole oil industry. It leaves them with a new realization and appreciation of the important role played by the genie who comes from a gasoline pump—instead of a lamp. And it does all this in 12 minutes!

Prints for your use are available at partial print cost or on extended loan through your Du Pont Petroleum Chemicals representative, or write to E. I. du Pont de Nemours & Co. (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

Petroleum Laboratory Facilities Expanded

Progress invariably involves change.

So you'll find some changes being made at the Du Pont Petroleum Laboratory at Deepwater, N. J. We are adding facilities so that we can keep pace with the increasing needs of the industry. Our intention is to improve the nature and scope of our service to customers.

These pictures will give you some idea of what has taken place.

Among the new facilities at our Petroleum Laboratory is this single-cylinder test engine room. You will find six engines, complete with the newest instrumentation, here.

Special projects, often undertaken in behalf of a customer, get the full attention of senior staff members who have ample room and facilities to work with their assistants in a new series of private labs recently added to the main Petroleum Laboratory.

Building a Flare Stack? How High Is "High Enough?"

How to figure ground level concentrations of toxic gases if the flare should be extinguished, where and when they might occur under different weather conditions are included in this important paper by F. T. Bodurtha, Jr.

Mr. Bodurtha is consulting engineer with the Engineering Service Division of Du Pont's Engineering Department. He consults on air pollution problems for existing and proposed new plants.

"Flare Stacks—How Tall?" discloses the latest and most reliable methods for computing stack heights needed for adequate disposal of contaminants with or without flaring, and taking into consideration such essentials as velocity of flare gases, thermal rise, wind speed, density, and surrounding topography.

A reprint of this paper, which appeared in the December 15, 1958 issue of *Chemical Engineering*, can be obtained by writing Petroleum Chemicals Division, E. I. du Pont de Nemours & Company (Inc.), Wilmington 98, Delaware.

New TEL Sidetrack for Philadelphia Area

The latest TEL sidetrack is on the Pennsylvania Railroad at Philadelphia. Deliveries from it will be made at any hour, day or night, to meet your emergencies or sudden needs.

Like the other 22 emergency shipping points, it will keep ample supplies of both motor and aviation mix on hand. For less-than-tank-car quantities, order from the truck terminals at Carneys Point, N. J.; Antioch and El Monte, Calif.; Beaumont, Texas; and Ferndale, Wash. For more information, contact your nearest sales office.

SALES OFFICES

Chicago 3—8 So. Michigan Ave.....RAndolph 6-8630
Cleveland 15—101 Prospect Ave.....MAin 1-3422
Houston 2—705 Bank of Commerce Bldg....CApitol 5-1151
Los Angeles 17—612 So. Flower St.....MAdison 4-1354
New York 20—45 Rockefeller Plaza.....COlumbus 5-2342
Philadelphia 2—3 Penn Center Plaza.....LOcust 8-3531
Pittsburgh 22—1 Gateway Center.....ATlantic 1 2933
San Francisco 4—111 Sutter St.....EXbrook 2 1934
Seattle 3—4003 Aurora Ave.....MElrose 2-6977
Tulsa 1—1811 So. Baltimore Ave.....LUther 5-5578
In Canada—Du Pont of Canada Limited, Petroleum Chemicals, 85 Eglinton Ave. East,
Toronto 12—Ontario.....HUdson 1-6461
OTHER COUNTRIES: Petroleum Chemicals Division, Export Sales, Wilmington 98, Delaware, PRospect 4-2962.

DU PONT
REG. U.S. PAT. OFF.

Better Things for Better Living
... through Chemistry

Du Pont Tetraethyl Lead and other Petroleum Additives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-12207

Printed in U.S.A.

Suppliers . . .

ant manager in Houston, has been promoted to branch manager there.

Mac W. Miller, who was area sales engineer for Union, has been promoted to division sales engineer in Dallas.

Charles K. Garvis, engineer for Union at New Orleans, has been promoted to division sales engineer with offices in Harvey, La.

Carroll T. Lancaster, formerly branch manager for Union, will have the same post at the M-C office in Harvey.

James W. Young, a former branch manager for Union, has been named branch manager at Lafayette, La.

Fran J. Hencke, who was area salesman for Union in Fort Worth, has been promoted to branch manager in Corpus Christi.

Lee O. Weaver, Tulsa salesman, has been transferred to the Midland, Texas, office.

H. R. Stoker, former branch manager for Union, has been appointed branch manager at the Nocona, Texas, office.

Merrill E. Bailey, formerly area manager for Union, has been promoted to sales supervisor and manager of sales in the Rocky Mountain area.

Thomas E. Goodwin will manage the branch at Hobbs, N.M.

Leonard L. Beck, formerly with Union, will be branch manager at Sterling.

L. R. Chester will retain his post of branch manager of the expanded organization's office in Oklahoma City.

Jack J. Frese, former sales engineer for Union, will be branch manager in Liberal, Kan.

SHAND AND JURS CO.'s Electrical Products Division has named **Bernard T. Wilson** chief engineer. He joined the company two years ago as manager of its Electrical Research and Development Department. In his new position he will coordinate and direct the development and design of new products.

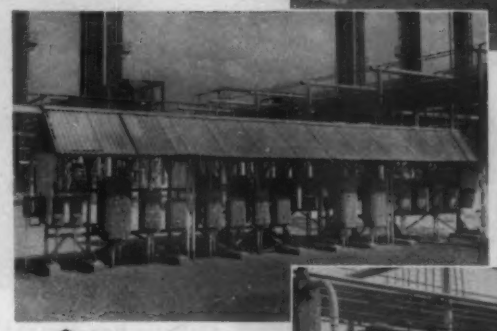
BAILEY METER CO has appointed **B. E. Gallagher** resident engineer in Indianapolis, Ind. He joined the company in 1946 as an engineering trainee and was assigned to the Chicago district after completion of his training. A graduate of Purdue University, he holds a B.S. degree in electrical engineering.

THOMPSON RAMO WOOLDRIDGE, INC. has acquired a controlling interest in Magnetic Recording Industries, New York. MRI has specialized in the development of electronic systems for teaching foreign languages and similar subjects. It will continue to operate autonomously as a subsidiary of TRW, becoming the fourth member of the corporation's Commercial Electronics Group.

THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS CO. has established a sales engineering office in Chicago, headed by central regional sales manager **Ray J. Stanish.** He will be responsible for all sales activities in the central United States. Stanish attended Case Institute of Technology, receiving a B.S. degree in

Right foreground: Nelson Class 1041, oil-immersed, 4160 volt motor starters

Left background: Nelson Class 497, factory-assembled switchrack, 480 volt



Nelson Class 497 switchrack with explosion-proof starters

Nelson 2000 KVA, double front, unit substation (explosion-proof)

Phillips Chemical Doubles Plant Capacity

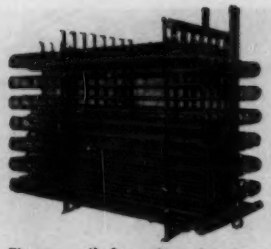
Editors of a leading magazine recently published a six page article on how Phillips Chemical doubled the production capacity of its Plains Synthetic Rubber Plant. They told how it was done and stressed the importance of selecting quality equipment to assure a high degree of reliability. In addition to the equipment pictured Nelson furnished such vital equipment as motor control centers, explosion-proof circuit breakers, combination starters, control stations and lighting panels.

Nelson takes pride in building quality into every job. If you are looking for a source of electrical control equipment that puts pride of workmanship above all, may we suggest you contact your Nelson Sales Representative. Offices are located in principal cities throughout the United States.

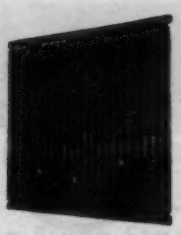
P. S. If you would like a print of the article mentioned please send your request to the factory. It will be mailed promptly.

At Nelson . . . . *quality* comes first!

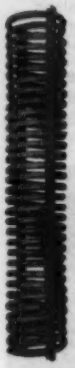
NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA



Zig-zag coil for submersion in rectangular tank. Design provides for efficient cooling of liquids in process plant.



"Blast" coil of 2" finned pipe for steel mill installation. Sized to heat 45,000 CFM from 60° to 140°F. when provided with steam at 50 psig. Hydrostatically tested to 100 psig prior to shipment.

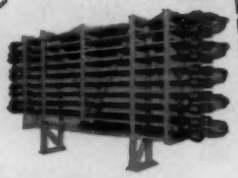


All pipe joints are welded with inert gas shield. Coils of stainless steel to operate at 9,000 psi at 650°F. Construction included heat treating to 2,000°F., X-ray of welds, pickling and passivating. Coil was tested to 18,000 psig hydrostatic.

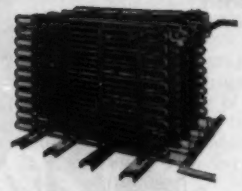
THE COIL FOR THE JOB!

Of any material from steel to silver, in any size, and for any purpose

Spiral copper evaporator coils, part of an order of 36 such coils. Well aligned, smoothly contoured . . . formed with oval or elliptical tubing.



Primary Aftercooler removes heat generated in compressing ethylene gas to 3700 lbs. per sq. in. Inner cooler tubes containing this pressure are heavy wall seamless steel with a cladding of Admiralty metal to protect the external walls from corrosion by water in outer pipes.



Coil assembly for brine service in quick-freezing foods required maximum surface in minimum space. Double layer ¾" O.D. internal zig-zag coils and single layer outer 1" O.D. zig-zags were brought into a 1½"IPS brass header.

Whitlock is fully equipped to fabricate coils of any size or material and to assemble and test them hydrostatically or by "air under water". Whether you require standard or special configurations, Whitlock can design and fabricate them quickly and economically.

Whitlock Engineers have had long experience in working with coils and have developed special techniques for welding standard materials as well as combinations of dissimilar metals. We are regularly designing and building coils for both high and low temperature services and for operating pressures ranging from a complete vacuum to several thousand pounds per square inch. Shown here are a few coils produced in our shop. We'll be pleased to make recommendations for *your* requirements.

THE WHITLOCK MANUFACTURING CO.
75 South Street • West Hartford 10, Conn.
In Canada: Darling Brothers, Ltd., Montreal

Whitlock

See our catalog unit . . . pages 1637-1644 . . . Chemical Engineering Catalog

DESIGNERS AND BUILDERS OF BENDS, COILS, CONDENSERS, COOLERS, HEAT EXCHANGERS, HEATERS, PIPING, PRESSURE VESSELS, RECEIVERS, REBOILERS.

Suppliers . . .

physics in 1945, a B.S. degree in mechanical engineering in 1950, and a M.S. degree in engineering mechanics in 1955. He was also an instructor in the Engineering Mechanics Department at Case. He was chief engineer of the Replacement Division of Thompson Products, Inc., Cleveland, prior to joining TRW Products in 1958.

AMCEL PROPULSION INC. has named **Julius P. Zeigler** vice president and general manager. He is presently with Celanese Chemical Co. as manager of high energy materials operations.

Zeigler was formerly chief of chemicals, propellants and explosives engineering development for the Department of Army Ammunition Command, with responsibility for the engineering of conventional and high-energy propellant systems for Army missiles. From 1954-59 he served as head of the Department of Defense group of technical experts to NATO for rocket missile propellants and explosives.

MIDWEST PIPING CO., INC. has appointed Oil Well Supply Division, United States Steel Corp., distributor for the Midwest line of welding fittings and flanges for refinery piping systems.

AMERICAN POTASH & CHEMICAL CORP.'s Dr. Donald S. Arnold has been named manager of research at Trona, Calif. He previously was head of the High Energy Chemicals Section of the AP&CC, Henderson, Nev., Plant Research Laboratory. At Henderson he was responsible for much of the company's research in high energy fuels.

TRUSCON LABORATORIES has presented awards for 40 years of service to **Terry Childs** of the Sales Department and **Roy Fiddler** of accounting. At a dinner held in their honor, each was presented an award and a gift.

W. W. CLARK CORP. has named **Willis W. Clark, II,** to its sales staff. He was previously packaging sales manager of The Dobeckmun Co., where he has been for 14 years. Clark is a graduate of Yale University, where he received his B.S. degree. He currently resides at 3120 Montgomery Road, Shaker Heights, Ohio.

ELLIOTT CO. has named **George J. Greaney, Jr.,** Houston district manager succeeding **J. D. Wilcox, Jr.,** who becomes Southern Region manager. Holder of an electrical engineering degree from Texas A & M College, Greaney joined Elliott in 1947 and became a field engineer in the Houston office after a year's training. From 1952-54 he managed the Corpus Christi office—then returned to Houston.

DIAMOND ALKALI CO.'s Chlorinated Products Division has named **Z. A. Stanfield** technical superintendent, Greens Bayou plant in the Houston area. Succeeding him at Belle as technical superintendent

PUMPAGE

Goulds news about pumps for process industries

Idea from a cosmetic bottle

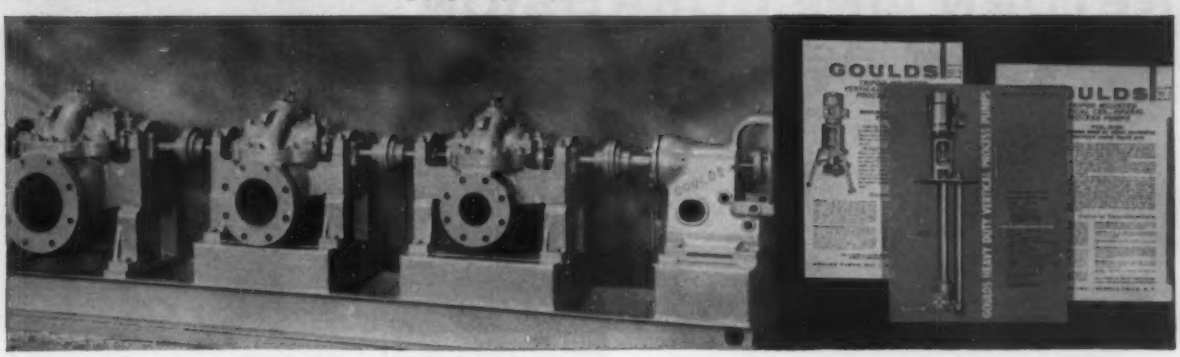
Cold wave lotion made from Evans Chemetics' thioglycolic acid comes to consumers in a bottle. A *glass* bottle. That set Evans to thinking: if *glass* prevents contamination in packaging, why can't it do the same job in *processing*? So they installed a Goulds-Pfaudler *glassed* pump. In it, glass is permanently fused to metal at every surface that contacts the pumpage. Result? Where expensive alloys were required to prevent contamination during processing, now smooth *glass* does the job . . . *better!* Maintenance and replacement problems ended too—for a full year after installation! Write for Bulletin 725.2.

Largest and smallest

The man dwarfed by the giant pump is a Goulds Application Engineer. Look closer. He's holding another pump, small enough and light enough to be held in one hand! His assignment: select the right pump for *your* specific need from all the pumps that fall within the range of Goulds' largest and smallest pumps. For instance—want to move a *lot* of liquid *fast?* That big job does it at *40,000 GPM!* Need a small, stainless steel pump that you can use 24 hours a day for chemical circulating or transfer work? Get as little as 1 GPM with the little pump. Cut pumping costs with the *right* pump for your job.

Pump with a built-in "steam bath"

When fat is a problem—try a steam bath! The steam bath we're speaking of keeps fats, wax, paraffin and other low-melting point solids *fluid* in your pumping system. It's "built-in" on the Goulds Fig. 3715 chemical pump to maintain high process temperatures—right at the pump. A steel steam jacket of full casing diameter keeps *all* the liquid in the pump hot. Can be furnished with new, or added to existing, pumps. You pump low melting point fluids or saturated salt solutions without "freezing"—to reduce down time in your operation. Write for Bulletin 725D17.



Tandem-mounted pump idea

Here's where it might pay you to put all your eggs in a single basket! One oil refiner set up four Goulds pumps *in tandem*, powered the whole works with one steam turbine. Advantages? The combined total horsepower allowed selection of a more efficient large turbine with reduced steam consumption—plus eliminating 3 turbines, bases and foundations. The two Goulds Fig. 3405 pumps in the center handle rich oil at 300 and 375 GPM respectively, with heads of 211 feet. At the left is a Goulds Fig. 3405 that pumps 600 GPM of lean oil at 248 ft. head. Pump on the right is a Fig. 3755 for supplying still reflux at 155 GPM and a head of 149 feet. All pumps and the turbine are mounted on a common steel base.

News about vertical process pumps!

Here's a complete rundown on what's new with heavy-duty vertical process pumps for handling corrosive liquids in the chemical process and allied industries. In many applications in the process field, the use of vertical pumps for transfer or other services offers many advantages. Advanced design provides for wet pit, dry pit and tripod-mounted pumps with maximum interchangeability of parts. These booklets list them all—and they're yours *free*. Just send to Goulds for your copy. Write Goulds Pumps, Inc., Dept. PR-119, Seneca Falls, New York.

GOULDS PUMPS

For more data on advertised products, use Readers' Service Cards, last page.

RETURN LINE CORROSION *Can* BE LICKED!

Drastic reduction of return line corrosion in an easy, effective and economical way has been the unanimous experience of hundreds of plants throughout the country using Bird-Archer's Amine Treatment.

A plant in New York State, generating approximately 500,000 lb. of steam a day, had a normal condensate pH value of 6.3 that resulted in almost constant piping replacements. Only 6 lb. per day of Bird-Archer's Amine Treatment cut maintenance costs to a new low by raising the pH value to the safe range of 8.0 to 8.5.

A plant in New England, generating 600,000 lb. of steam a day, did not have an open feedwater heater which would mechanically eliminate the exceedingly high CO_2 content of their makeup water, consequently, the pH value of their condensate was sometimes as low as 5.9. Less than 12 lb. of Amine Treatment a day raises the pH value of the condensate to 8.5, eliminates excessive corrosion.

After two years of experience with Amine Treatment a power plant in Massachusetts, making 250,000 lb. of steam a day, enthusiastically reports that they eliminate over 75% of their piping replacements through the use of only 2 or 3 lb. a day of Amine Treatment.

Return line corrosion has been licked at these plants. Let a Bird-Archer Service Engineer help you solve *your* corrosion problems.

Write for Bulletin CP100 and the name of the Bird-Archer Service Engineer nearest you.

BA-801

BIRD-ARCHER
WATER TREATING CONSULTANTS
The BIRD-ARCHER Company, 4337 N. American St., Phila. 40, Pa.
New York • Chicago
The BIRD-ARCHER Co. of California, 415 Brannan St., San Francisco
Offices in Canada and Mexico

Suppliers . . .

is **D. R. Pulver,** senior engineer with the division's technical staff, Cleveland. Replacing Pulver on the technical staff is **V. C. Cayton,** a process engineer at Diamond's Deer Park, Texas, plant since March, 1955. Moving into Cayton's post as process engineer, Deer Park, is **G. E. Taylor,** who recently completed the company's year-long engineer training program.

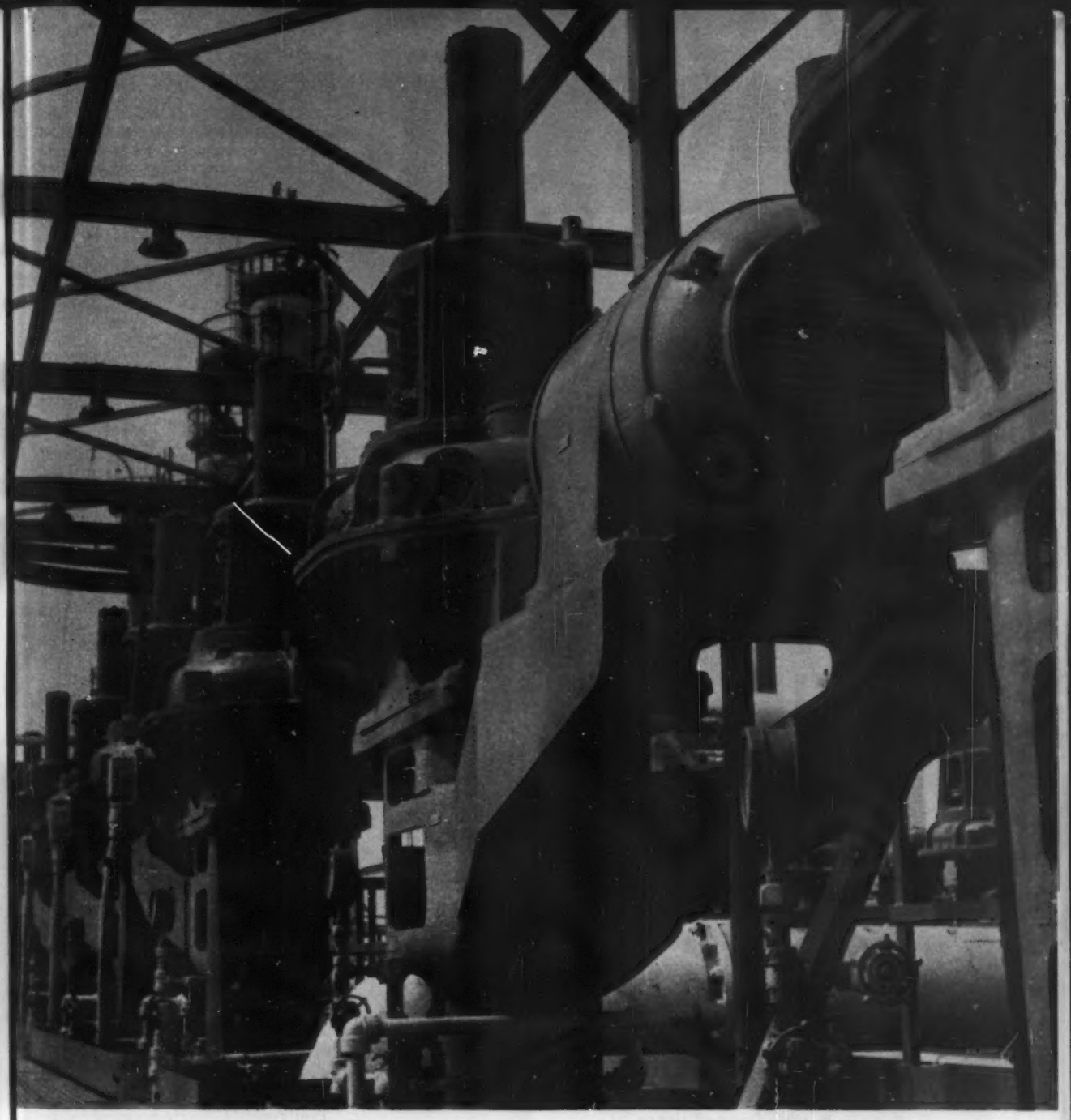
CHEMETRON CORP. has named **Edmund W. Dugan** to head a Washington, D.C., office. The office, in the new Moreschi Building, 905 16th Street, N.W., will handle business in Washington for the corporation. Previously business manager for Chemetron's Girdler Catalysts operation, Louisville, Ky., he recently served as assistant director of the General Industrial Equipment and Components Division, Business and Defense Services Administration, U.S. Department of Commerce.

EBASCO SERVICES, INC. has named **A. W. Peabody** supervising engineer of the Corrosion Engineering Group. With Ebasco for 22 years, he first joined the company as an engineer engaged in electrical design of steam and hydroelectric plants. Since 1939 he has concentrated on various corrosion engineering projects for utility and industrial companies. A graduate of the University of Maine and a licensed professional engineer in New York, he is a member of AIEE, NACE and AGA.

CHICAGO BRIDGE & IRON CO. has formed a company in the Netherlands to erect large steel plate structures fabricated there. The company, headquartered in Rotterdam, is Chicago Bridge (Nederland) N.V. The new organization is a subsidiary of Chicago Bridge, Ltd., London, a subsidiary of Chicago Bridge & Iron Co.

MINNEAPOLIS-HONEYWELL REGULATOR CO.'s Instruments Division, Philadelphia, has named **Frank P. Kelly** manager of manufacturing operations. He succeeds **Frank M. Rea,** who has been assigned to Honeywell's Industrial Products Group as a consultant in industrial engineering,

Use readers' service postcard, page 467, for more information on advertised products



The new look in alkylation

Breaking the skyline at Linden, N. J., is a new silhouette. It's the outline of 42 big 50-hp LIGHTNIN Mixers atop huge alkylation reactors at Esso Standard Oil Company's Bayway refinery.

These mixers deliver a powerful, steady turbulence that instantly disperses incoming olefins, keeps hydrocarbons from separating anywhere in the reactor, promotes maximum acid economy and light alkylate yield. The mixers operate continuously, 24 hours a day.

To the success of this process MIXCO engineers contributed many hours of research into the fluid mechanics of alkylation, and specialized knowledge of mixer impeller performance under varying reactor conditions.

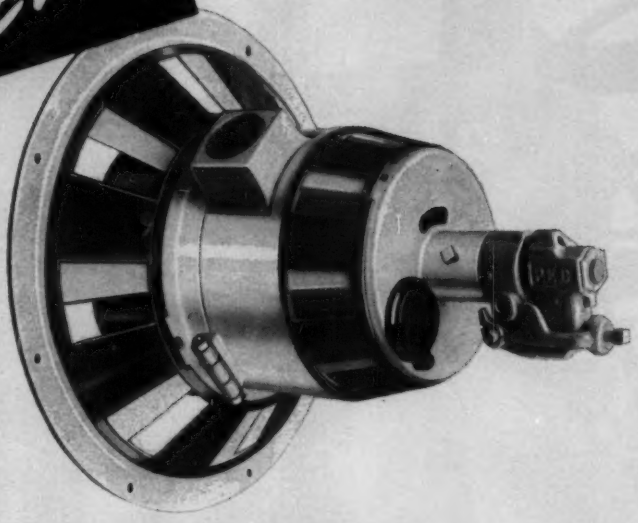
When you are designing a process or fitting out a plant, you can count on the same skills—in fluid mechanics and in equipment design—to minimize your operating costs. Your LIGHTNIN Mixer representative can give you full details. Or write to us in confidence.

Lightnin® Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 164-m Mt. Read Blvd., Rochester 3, N. Y. In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont

NEW!



PEABODY FLEXIPRO BURNER

for firing oil and gas separately or SIMULTANEOUSLY

The Peabody Flexipro (flexible process) refinery burner is a natural draft burner for vertical or horizontal firing. It is short, compact, readily accessible, and has a simple rugged dual air register.

The Flexipro burner features:

- **Readily removable fuel units**
- **Maximum availability**
- **Low maintenance**
- **Positive air flow control**
- **High firing efficiency**
- **Excellent stability at adverse fuel-air ratios**

It is suitable for capacities from 2,000,000 to 16,000,000 B.T.U./hr.

Write today for complete information.

P-437

PEABODY ENGINEERING CORPORATION

232 MADISON AVENUE, NEW YORK 16, N. Y.

OFFICES IN PRINCIPAL CITIES

SUBSIDIARIES
In England: **PEABODY LIMITED** *In Canada:* **PEABODY ENGINEERING CORPORATION OF CANADA LTD.**

Suppliers . . .

tooling and subcontracting. Kelly joined Brown Instruments Division in 1943 and has held a number of posts, including that of purchasing agent, manager of manufacturing assembly operations, and general superintendent. He is a graduate of St. Joseph's College, Philadelphia.

H. K. PORTER CO., INC.'s Refractories Division opened its new Pascagoula, Miss., works on Sept. 18. More than a hundred state and local officials and members of the press attended. After viewing a 13-minute film pictorializing construction of the plant, guests toured plant facilities under the guidance of 12 production supervisors, who explained technical aspects of plant operation to visitors.

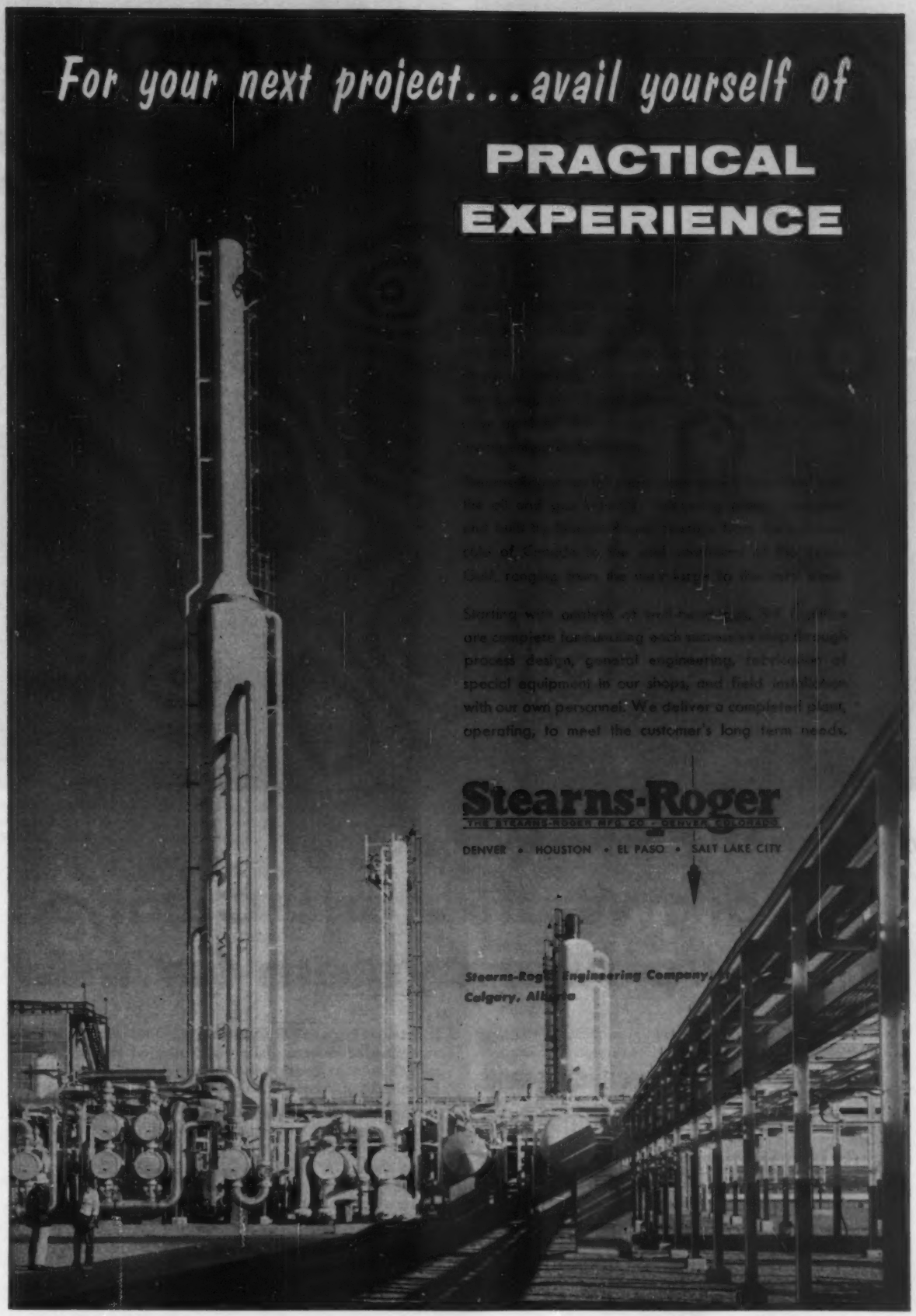
GENERAL ANILINE & FILM CORP.'s Dyestuff and Chemical Division has named **Dr. C. C. Schulze** assistant general manager. He was formerly manager of manufacturing of the division. Schulze will coordinate long-range expansion projects from research to commercialization for the Dyestuff and Chemical Division. He joined General Aniline as a research chemist at the Linden, N. J., plant in 1942 and since has held various executive positions covering all phases of the company's research and manufacturing operations. He was promoted to plant manager of the division's manufacturing operations at Rensselaer, N. Y., in January 1955 and in June 1956 was appointed manager of manufacturing for the division. A graduate of Nebraska State Teachers College with a B.S. degree, Dr. Schulze has M.S. and Ph.D. degrees from the State University of Iowa.

KEASBEY & MATTISON CO. has appointed **Richard E. Lander** project engineer in its Investigation, Standardization and Improvement Department, Ambler, Pa. Before joining the company, he was with Harris-Dechant Associates, Philadelphia, Consulting Engineers. A graduate of Tufts University, Lander holds a degree in civil engineering and is a registered professional engineer.

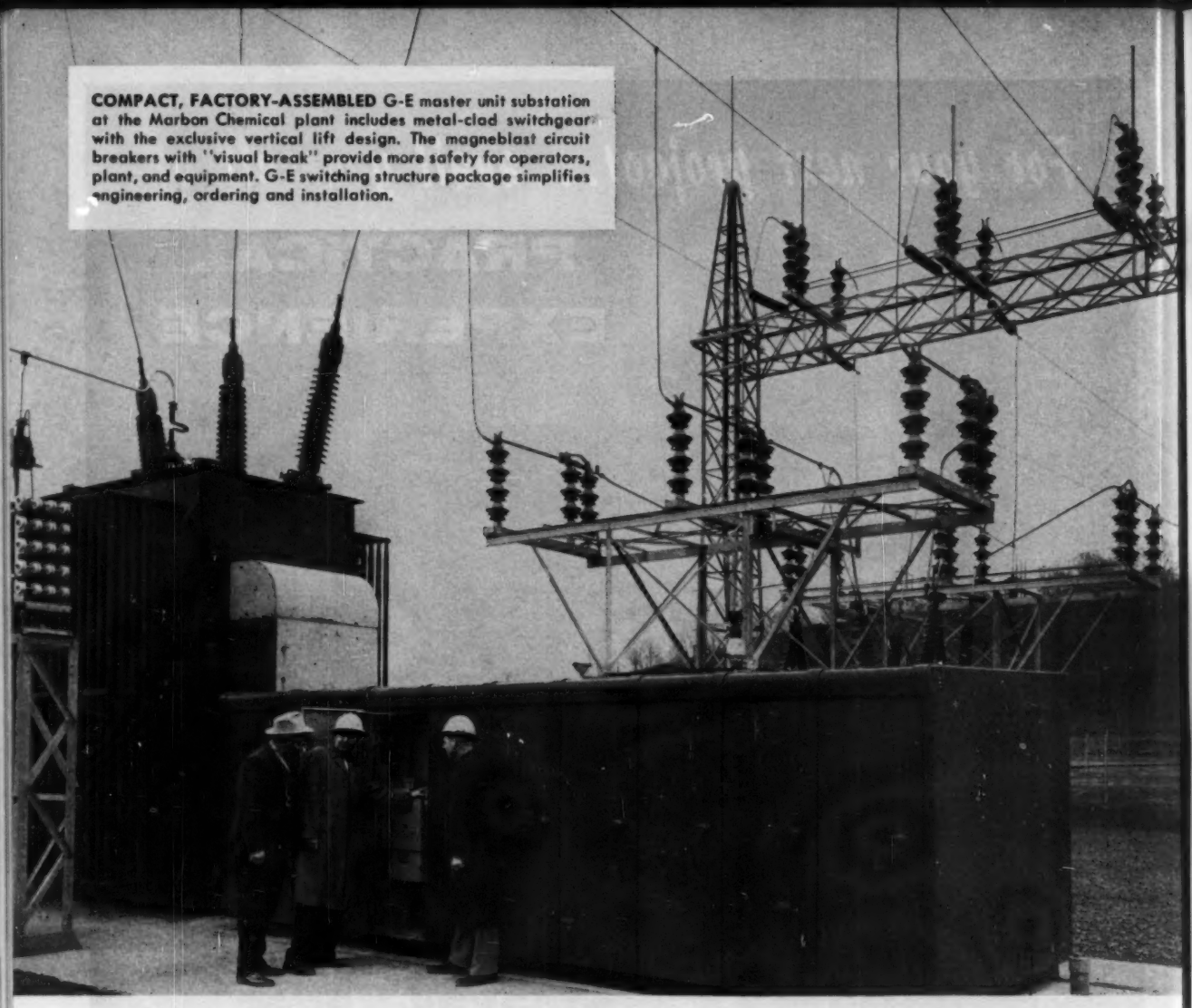
Albert W. Spedding has been named chief project engineer in the Central Engineering Division. He has spent the last ten years directing major project work for various asbestos companies.

Paul Foulds, formerly laboratory technician in the Research and Development Division, has been promoted to products supervisor in the Quality Control Division. He joined K&M in June, 1958.

ALLIS-CHALMERS MANUFACTURING CO.'s Russell A. Hedden has been appointed works manager of manufacturing, Industries Group, West Allis, Wis., works. He succeeds **E. W. Bonness** who has been named consultant to the director of manufacturing, Industries Group. Hedden formerly was works manager of the company's York, Pa., works, a position he held since 1957. A 1941 graduate of the Newark College of Engineering, Hedden has a background of financial, engineering, research, design and consulting


For your next project... avail yourself of
PRACTICAL
EXPERIENCE
Stearns-Roger
THE STEARNS-ROGER MFG. CO. • DENVER, COLORADO
DENVER • HOUSTON • EL PASO • SALT LAKE CITY
Stearns-Roger Engineering Company,
Calgary, Alberta

For more data on advertised products, use Readers' Service Cards, last page.



COMPACT, FACTORY-ASSEMBLED G-E master unit substation at the Marbon Chemical plant includes metal-clad switchgear with the exclusive vertical lift design. The magneblast circuit breakers with "visual break" provide more safety for operators, plant, and equipment. G-E switching structure package simplifies engineering, ordering and installation.

TO HELP ASSURE EARLY PRODUCTION OF CYCOLAC® . . .

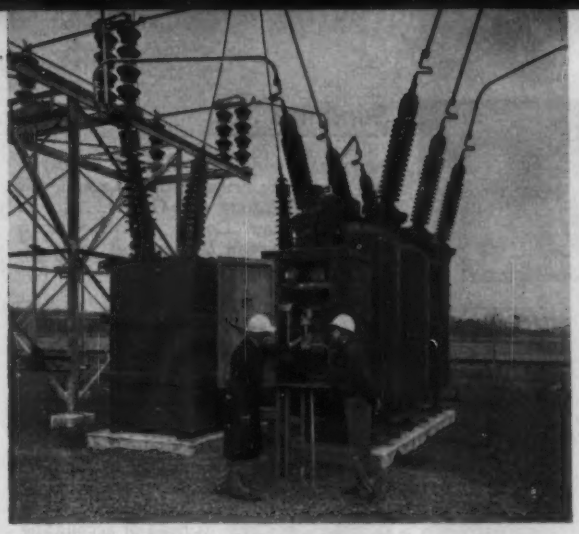
Borg Warner and Catalytic power system for new

Single-source purchasing and coordinated system components cut installation time and costs, provide peak performance and longer life.

Marbon Chemical Division of Borg Warner Corporation needed a new plant—and needed it fast. Every month lost in construction time meant lost sales for Cycolac®, its new high-impact thermoplastic resin.

Catalytic Construction Company of Philadelphia was given design and construction responsibility for this 65-acre, $10,000,000 plant in Washington, W. Va. To help them meet the close deadline, General Electric engineers worked closely with Catalytic's purchasing and engineering personnel in the system engineering, ordering, and scheduling of the power distribution and drive equipments.

With single-source purchasing, Catalytic saved time and engineering costs and Marbon made important cost savings on construction and production. By giving



DEPENDABLE G-E oil circuit breaker permits easy access to operating mechanism, is shipped assembled for easier handling, faster installation. G-E disconnect switches are designed for all-weather operation.

GREATER EFFICIENCY AND ECONOMY result from easy-to-install G-E motor control unit substation, providing centralized control of small processing motors from a remote location. Compact design saves valuable floor space.

EASY-TO-MAINTAIN G-E Limitamp* control (right) withstands severe repetitive duty, handles medium horsepower motors. Smaller motors are controlled by motor control (left).

RUGGED, RELIABLE totally-enclosed, fan-cooled G-E Triclad* induction motor (75 horsepower, 220/440 volt) drives air compressor for instrument control.

chose General Electric Marbon Chemical Plant

electric equipment project responsibility to General Electric, work began earlier on the standardized units for the new plant's power distribution package. The power package arrived on schedule at the plant site, permitting the process area to go on stream before the whole plant was completed. In addition, General Electric installation and service engineers worked with Catalytic and Marbon engineers during plant start-up.

The pre-assembled, complete-packaged nature of G-E substations, switchgear, motor-control centers and motors greatly simplified installation. Need for expensive, specially protected equipment was eliminated by using G-E motor-control centers for control of processing motors from a central location. In addition, standardization on General Electric equipment permitted Marbon maximum spare parts interchangeability and reduced inventories.

For more information on General Electric system-engineered equipment and technical assistance, contact your nearest General Electric Apparatus Sales Office or write to General Electric Company, Section 681-17, Schenectady 5, N. Y.

Ⓡ *Registered trademark of Borg Warner Corp.*
**Registered trademark of General Electric Co.*

Engineered Electrical Systems for the Chemical Industry

GENERAL ELECTRIC

Petroleum Refiner New Classified Rates

RATES: Regular Classified (undisplayed) set in this type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. Display Classified ads, set in suitably larger type with ruled border $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. All Classified ads payable in advance. Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

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HELP WANTED

MAINTENANCE EXPERT WANTED FOR PARIS

If you are highly qualified and have outstanding background and experience to organize and direct refinery maintenance organization in Europe, with headquarters in Paris, please call, wire or write. Retired maintenance Manager of large oil company or top maintenance engineer, interested to work in Europe invited to apply, stating age, experience and all details in first letter. Box 327-R, PETROLEUM REFINER, Houston, Texas.

Manufacturer of materials for pipeline protection now expanding sales force into Northeastern Region offers permanent, lifetime franchises to sales agencies contacting pipeline, public utility refining and chemical industries. New England, North Jersey, Philadelphia, Baltimore, Pittsburgh and Cleveland areas available in this ground floor opportunity. Box 325-R, PETROLEUM REFINER, Houston, Texas.

CHEMICAL OR MECHANICAL ENGINEER, Eastern U. S. Manufacturer requires experienced Engineer for Process and Mechanical Design of Fired Heaters. Age 30-40. Minimum Experience—5 years. Ch.E. or M.E. degree preferred. All replies to Box 323-R, PETROLEUM REFINER, Houston, Texas, will be treated confidentially.

■ Corrosion - Metallurgical - Inspection - Welding Engineer. Seven years major refining, petrochemical plants. Supervisory experience. B.S. Met.E. Age 30. $10,000 present. Box 324-R, PETROLEUM REFINER, Houston, Texas.

MANAGER

Engineering Contracting Company, well financed, good reputation, needs general manager. Good opportunity available for a man experienced in industrial, petrochemical and refinery engineering and construction.

All replies held in confidence. Submit resume to Post Office Box 2963, Houston 1, Texas.

PROCESS ENGINEER

Engineering graduate experienced in the process design of various types of petroleum refining process units required by a midwestern engineering and construction firm. Please submit resume and photograph indicating education, experience, and salary requirements to Box 322-R, PETROLEUM REFINER, Houston, Texas.

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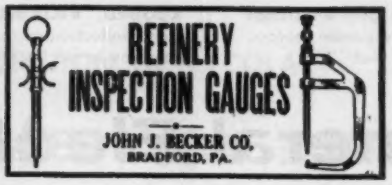

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experience with a number of industrial and consulting firms. Included among his former affiliations are General Motors Corp.; Carrier Corp.; Curtiss-Wright, Stevenson, Jordan & Harrison, Management Consultants; and the National Industrial Conference Board.

CHEMETRON CORP.'s Chemical Products Division has named **Orion A. Jones, Jr.,** controller. He will headquarter in Louisville and will continue to direct Girdler Catalysts' Accounting Department in addition to his new duties as head of accounting activities for other units of the Chemical Products Division. These include Holland Color and Chemical Co., Holland, Mich.; Dunham Chemical Co., Chicago; and Crestwood Chemical Co., Rock Hill Laboratory, Newport, Tenn. Jones was with the Federal Land Bank before joining Girdler in 1941.

Jones

UNION CARBIDE CORP.'s Linde Division will build another liquid oxygen-nitrogen plant to supply missile installations with cryogenic fluids. Located near the missile engine production facilities at Fort Crowder Reservation, Neosho, Mo., the plant will be capable of producing 135 tons per day of liquid oxygen and nitrogen. Engineering work has been completed and the project is slated to be operating in about a year.

CRANE CO. has acquired all properties and assets of The Chapman Valve Manufacturing Co., Indian Orchard, Mass. This provides Crane with manufacturing facilities in the Eastern United States, something it has not had since 1941 when its Bridgeport, Conn., plant was sold. The sale price of $11.2 million was approximately book value, and included $4.2 million for fixed assets. The plant will retain its present management and executive staff.

UNITED STATES RUBBER CO. and Derby Refining Co. have completed arrangements for the sale of U.S. tires, batteries and automotive accessories through Derby outlets. Under the agreement, the complete line of U.S. Rubber tires will be marketed in all areas served by Derby dealers and jobbers.

THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS CO. has added **Ira C. Gunning** to its staff. He attended the University of Oklahoma, receiving his B.S. degree in physics and M.E.E. degree in 1949. He is a member of Tau Beta Pi and the Radio Technical Commission for Aeronautics. Prior to joining TRW Products, Gunning held engineering positions with the Convair Division, General Dynamics Corp., Pomona, Calif., and the Naval Air Test Center, Patuxent River, Md.

U.S. INDUSTRIES, INC. has concluded arrangements for acquisition of Burtonwood Engineering Co., Ltd., of Lancashire, England, for an undisclosed sum. The acquisition gives USI its first wholly-controlled manufacturing business in the European market area. The Burtonwood Co. has three plants in England and a subsidiary company in Venezuela. It manufactures products in the oil field equipment line, automotive, plastics and material-handling industries.

GENERAL ANILINE & FILM CORP.'s Dyestuff & Chemical Division has named **Joseph W. Conlon** director of manufacturing, New York. He was formerly plant manager of the division's manufacturing operations, Rensselaer, N. Y. Before joining the Analytical Department of the Rensselaer plant in 1936, Conlon was with Technicolor Motion Pictures Corp. following graduation from Notre Dame University in 1935 with a B.S. degree in chemical engineering. He has been with the Rensselaer plant for about 20 years and has held executive positions there in research and manufacturing. Conlon was made production manager of the Rensselaer plant in 1950 and plant manager in 1956.

ALUMINUM CO. OF AMERICA's Ellis D. Verink, Jr., has been named manager of chemical and petroleum industry aluminum sales. Formerly manager of the Chemical Section, Sales Development Division, New Kensington, Pa., since 1948, he will move to company headquarters, Pittsburgh. Verink will coordinate a program to advance new and more effective aluminum applications in the chemical and petroleum industries. Holder of a B.S. degree in metallurgical engineering from Purdue University, he joined Alcoa in 1946 as an engineer in the Sales Development Division, and became manager of the Chemical Section two years later.

COLUMBIA-SOUTHERN CHEMICAL CORP.'s Richard C. Oswant has been named manager of advertising succeeding **James C. Plunkett,** who has been manager of advertising for Columbia-Southern and Pittsburgh Plate's Fiber Glass Division. Oswant was editor of Columbia-Southern's *Chemicals* magazine during the past three years. He will continue as editorial director of the external publication. Oswant is a graduate of Carnegie Institute of Technology and a member of the National Industrial Advertisers Association.

CHASE BRASS & COPPER CO.'s Cleveland Mill Division has named **Paul R. Totten** works manager. He comes to Chase from the Allenport works of Pittsburgh Steel Co., where he had been divisional superintendent. Totten is a graduate of College of Wooster with a B.A. degree in chemistry, and of Ohio State University with a M.S. degree in metallurgy. After graduation he joined Pittsburgh Steel Co. as plant metallurgist, Thomas Strip Division, Warren, Ohio. In February 1955, he was promoted to the Allenport Works as divisional superintendent.

R-P&C Lubrotite Valves
end double valving... cut valve costs

• Illustrated above is a lubricated gate valve designed for use in HF Alkylation service.

Here are some advantages you get when you install R-P&C Lubrotite Gate Valves to handle gasoline, oil, benzol, HF Alkylation and other critical fluids:

1. **Positive tightness.** Properly lubricated valve *remains tight* even if seat is damaged by foreign matter in line.
2. **Protection from corrosion.** In the unique Lubrotite system, the lubricant retards corrosion, prevents sticking and leakage, makes for easier operation.
3. **Ends need for double valving.** Lubricant forms more positive seal and gives better shut-off than double installation or regular gate valves.
4. **Factory testing.** Lubrotite valves are factory-tested, without lubricant, before shipment.
5. **Versatility.** Suitable for gas, air, water, certain chemicals, and many other fluids.
6. **Double economy.** Lubrotite gate valves not only help reduce your operating costs; they cut replacement costs, too.

A FULL VALVE LINE

R-P&C Distributors offer users in the petroleum industry a complete line of R-P&C valves in all standard materials—plus many specialties. See your nearest R-P&C Distributor—or write

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R-P&C Valve Division, American Chain & Cable Company, Inc.

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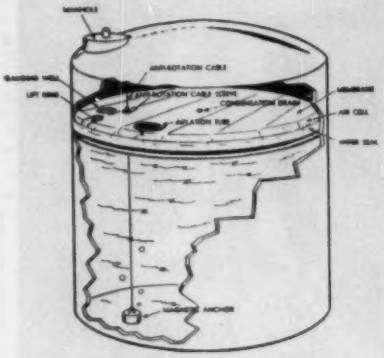
For more data on advertised products, use Readers' Service Cards, last page.

New Equipment & Literature...

Resin-Coated Fabric Makes Vapor Seal



A new line of resin coated fabrics is currently being used to fabricate vapor seals which float on the surface of high octane automotive fuels to cut down losses due to evaporation. Such seals have remained in gasoline storage tanks for more than a year with no sign of degradation.

Called "Irvington" brand coated fabric 4222, the new material is coated with a modified polyester resin applied to nylon, dacron and glass cloth or other types of fabrics in various weaves to provide desired burst and tear strength properties.

It has "superior" sunlight and ozone resistance, remains flexible at minus 80° F, will operate at 375° F without degradation and has "excellent" resistance to mildew, wind and salt water. Its abrasion resistance is called greater than all other commonly used coatings, with very high adhesion to base cloth.

The new fabric has excellent solvent resistance to aromatic, aliphatic, ketones and esters at room temperature. It is resistant to jet fuels, synthetic ester oils and hydraulic fluids as well.

Flexibility of the material is permanent since it contains no plasticizers which could bleed out with age. Minnesota Mining and Mfg. Co.

Circle E1 green card, last page

High Reforming Activity With New Catalyst

A highly active new nickel base catalyst, G-56, said to increase capacity or improve operating efficiency in reforming of lower molecular weight hydrocarbons, has been developed.

Greater reforming activity of the new catalyst, which has been commercially proven, permits either greater throughput at the same temperatures or else reduced operating temperatures at the same throughput. The G-56 is used for processing with steam, carbon dioxide, or steam and air at temperatures from 1,100 to 2,100° F and pressures from near atmospheric up to 320 psig.

Commercial applications include production of high-purity hydrogen, ammonia and methanol synthesis gases, special-ratio hydrogen-carbon monoxide synthesis gases, reducing and inert atmospheres and utility carrier gases, the company said, especially where trouble-free operation is threatened by carbon deposition and where the feed stock contains unsaturates. Feed stock can include natural gas, low molecular weight hydrocarbons, refinery gas, coke oven gas and refinery propane.

The G-56 contains no sulfur and does not require preactivation before being placed on stream. It is not affected by exposure to temperatures as high as 2,200° F and does not fuse at temperatures of 2,500° F. Physical strength is substantially greater than that of previous catalysts of this type. Girdler catalysts.

Circle E2 green card, last page

Lead and Manganese Form New Antiknock Compound

A new additive for automotive gasoline that combines lead and manganese to form the most effective antiknock compound to be marketed in over 35 years has been announced.

Known as "Ethyl" Antiknock Compound—TEL—Motor 33 Mix, the new product consists essentially of a mixture of tetraethyl lead and methylcyclopentadienyl manganese tricarbonyl. The latter is one of the organic compounds of manganese which promotes the antiknock action of tetraethyl lead.

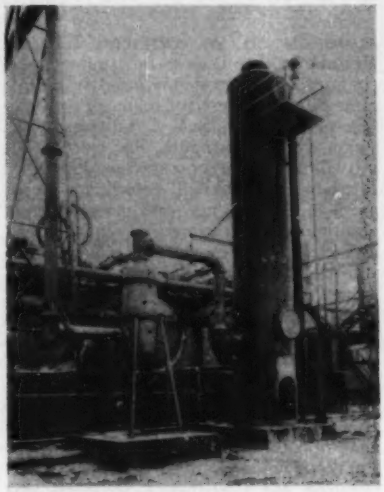
The new product can be handled in the same tetraethyl lead mixing plants already installed in refineries, without any change in equipment.

It is now being made available to refiners in commercial quantities for motor fuels. Ethyl Corp.

Circle E3 green card, last page

Compact Scrubber Replaces Two Conventional Towers

Eliminating the air pollutant from asphalt refining more efficiently and economically with less maintenance and non-fouling of the scrubbing operation is resulting from the new WD

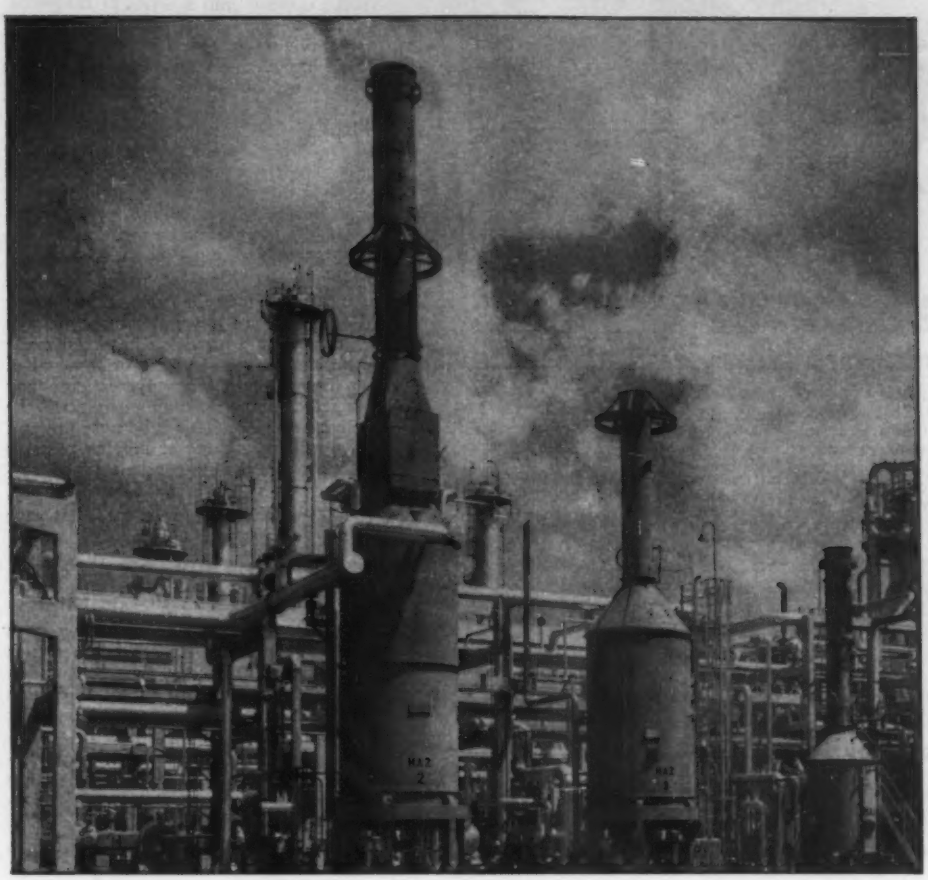


Scrubber, now in operation at the Port Neches, Texas Plant of Texaco, Inc.

Made entirely of monel except for its flanges, this scrubber is built to withstand the high temperatures required in this process. With no filters, screens or moving parts, this unit scrubs out the oil and asphalt carryover from the contaminated gas entirely by the centrifugal separating action of the patented helicoid and scrubbing tuyeres.

Contaminated gas upon entering the vessel spreads out in the lower chamber and is combined with water. Passage through the scrubbing tuyere blades imparts a rotary motion to the contaminated gas. This is thoroughly

JEFFERSON CHEMICAL COMPANY SELECTS BORN HEATERS



We are proud to have been selected to furnish Born Heaters for the process heating requirements at this new Jefferson Chemical Company facility.

For over 42 years Born has specialized in the field of process heating. During this time Born Heaters have built a reputation for producing day after day with no expensive "down-time."

For the complete story on a BORN HEATER to fit your needs, write, wire or call your BORN representative. He is anxious to serve you.

Born process heaters are specified time and again by leaders in their fields. In the Petrochemical industry, Born has furnished heaters for the following distinguished clients:

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Aluminum Company of America
American Cyanamid
Celanese Corporation of America
The Celotex Corporation
Chemical Solvents Company
Dominion Tar & Chemical Company
Julius Hyman & Company
Koppers Company
National Petrochemical Corp.
Texas International Sulphur Co.
Velsicol Chemical Corporation
Witco Chemical Company
Wyandotte Chemical Company

BRANCH OFFICES:
Denver, Colorado; Houston, Texas; Los Angeles, California; New York, New York; Shreveport, Louisiana

IN CANADA:
Canadian Brown Steel Tank Co., Ltd. Brandon, Manitoba, Canada

IN GREAT BRITAIN:
H. & E. Lintott, Ltd. Horsham, Sussex, England

IN FRANCE:
Sacama Paris, France

BORN Engineering Company
Manufacturers of Direct-Fired "UPFLO" Heaters
TULSA, OKLAHOMA

For more data on advertised products, use Readers' Service Cards, last page.

A UNIQUE CHECK VALVE THAT'S UNSURPASSED IN WATER, AIR, OIL OR GAS SERVICE

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Technocheck®

OUTPERFORMS • OUTWEARS OTHER VALVES • COSTS LESS TO MAINTAIN

In field service in a wide range of water, gas, air and oil applications, Technocheck's performance and reliability are unsurpassed. Its exclusive design eliminates valve seats. Tight sealing, low pressure drop and long life with low upkeep are some of its important characteristics.

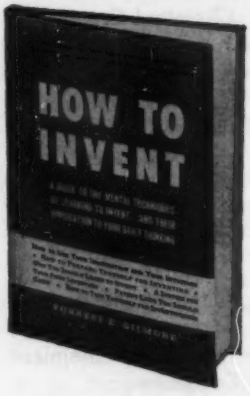
SCHEDULE OF STANDARD VALVE SIZES

GENERAL DESCRIPTION	PSI	SIZES
Cast, Iron Flanged	125	4", 6", 8"
Steel, Male Threaded Ends	150	1½", 2", 2½", 3"
Steel, Flanged	150	3", 4", 6", 8"
PVC, Male Threaded Ends	125	1½", 2", 3"
PVC, Flanged	125	2", 3"
PVC, Flanged	50	4", 6", 8"

We invite inquiries on other sizes and in special materials.

Techno Corporation Dept. PF
16 West 5th Street, Erie, Pa.

Just Because You Have Never Invented Anything Does Not Mean You Have No Talent For It.



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A guide to the mental techniques of learning to invent . . . and their application to your daily thinking.

In easy-to-read and understand language this book shows you: how to use your intuition and imagination, how to prepare for invention, how to test your Ingenuity Quotient, when and where to invent, how to find time to invent, ways to profit from your invention, how to record your observations, why some potential inventors fail.

The book also contains a detailed discussion of patent practices you should know such as: how to decide what is patentable, how to go about obtaining a patent, what a patent really means, how to protect your patent from the beginning.

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Equipment . . .

mixed with the water spray, and emulsified contaminants are thrown onto the inner wall of the vessel and down into the reservoir for removal.

The gas leaving the scrubbing tuyere passes upward into a series of tangential slots in the upper or drying tuyere. Any contaminants carried over from the scrubbing element are removed in this drying tuyere. Provision is made for ready cleaning of the outer surface of this tuyere by means of a second set of sprays. These contaminants enter a second annular raceway and discharge through the drying stage drain, leaving only the clean gas to move to the atmosphere free of contamination.

Compactness of the design permits the use of material resistant to corrosive agents inherent in the gas, and at a lower initial cost than the nonresistant units it replaces. While provision has been made in design for the servicing or removal of the internal scrubbing tuyeres, company engineers state that maintenance will be almost negligible. This is because the unit has no filters, screens or moving parts, is self-cleaning and is constructed of corrosion-resistant materials. Centrifix Corp.

Circle E4 green card, last page

Solid State Computer Data Included In Brochure

"Analog Computer CM-2," a two-page brochure describes and illustrates this solid-state computing device for mathematical calculations, especially applicable in the chemical, petrochemical, refining and process industries. It lists all technical data and specifications, including special amplifiers and networks which are available. Southwestern Industrial Electronics Co.

Circle E5 green card, last page

Improved Catalyst For Selective Hydrogenation

Development of two new selective hydrogenation catalysts, G-55 and G-58, has been announced.

Both are promoted palladium catalysts, improved versions of the company's established G-46 catalyst.

G-55 is used for selectively hydrogenating methyl acetylene and propadiene in concentrated propylene streams. G-58 is used for selective hydrogenation of acetylene in concentrated ethylene streams. Both have long operating cycles between regenerations and are capable of operation with ratios of less than two-to-one of hydrogen addition.

For the new G-55 catalyst, the company said, operating cycles of over six months between regenerations are possible because polymer formation is reduced to a minimum. High selectivity results in no loss of inlet propylene. No special treatment or activation procedures are required before placing the catalyst

This Man Can Help You Get More Efficiency From Plant Equipment

Efficiency is what you want from your plant equipment, and the Dowell engineer can help you get it. Plants in every major industry—for example, oil refining, chemical, public utility, steel and paper—are getting productive results from *economical* chemical cleaning by Dowell.

To remove scale and sludge from your process equipment, boilers, tanks and piping, Dowell engineers provide knowledge and tools you can get from no other chemical cleaning service. You get cleaning knowledge gained from developing and working with the rigorous cleaning standards of the missile program at Cape Canaveral. You get new tools and chemicals from a continuous research program. For example, Dowell recently introduced a new high-velocity jetting device for cleaning tube bundles.

And you get 20 years' worth of experience in all types of industry from Maine to California. Plant operators find it pays to call Dowell on even the smallest job. But they also know that Dowell has the manpower and equipment to clean the largest and most complex systems.

The Dowell engineer takes pride in doing your job so well that you will continue to call him for your cleaning work. This desire to do your job well covers every facet of service—from seeing that you get solvents exactly as specified, to supervising Dowell's full-time safety program. Every precaution is used to protect your personnel and equipment.

Prompt service and detailed information is yours from any of the 165 Dowell stations and offices. Get more efficiency—economically—with the help of the largest, the oldest, the most experienced chemical cleaning service—Dowell, Tulsa 1, Oklahoma.

Chemical cleaning service for all industry

DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

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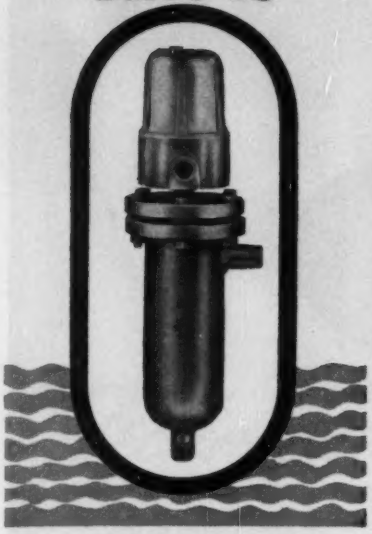

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Send full information on Level Master and name of nearest representative.

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Equipment . . .

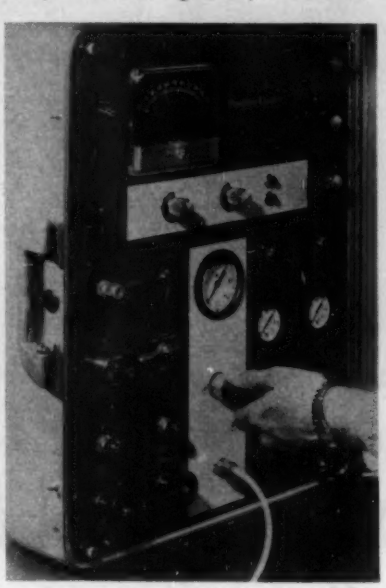
on stream. Space velocities up to 1,500 volumes of inlet gas per hour per volume of catalyst are achieved and the catalyst operates at temperatures as low as 130° F and pressures up to 350 psig.

The G-58 catalyst achieves operating cycles of from 30 to 40 weeks. It will operate at inlet temperatures as low as 75° F and pressures from 200 to 400 psig with space velocities up to 2,000 volumes of dry gas per hour per volume of catalyst. Girdler Catalysts.

Circle E6 green card, last page

Leak Detector Is Sensitive To 0.1 Parts Per Million

A completely self-contained portable hydrocarbon detector affording rapid analysis of total organically bonded car-



bons in atmosphere or gases has just been developed.

Unique characteristics of the new instrument make it highly suitable for use as an atmospheric monitor of air pollution or lower explosive limits. The unit, which has been designated the P-E Model 213, will also serve effectively as a leak or impurity detector in lab, field and processing systems. Cost of the instrument is less than a third that of equipment normally employed in these functions.

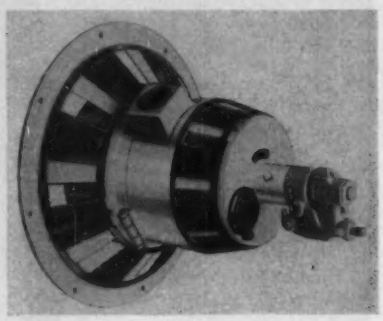
Sensitivity of the new instrument is better than 0.1 parts per million for such organic carbon compounds as hydrocarbons, aldehydes, ketones, alcohols, amines etc. It is completely free of interference from such common backgrounds as water vapor, oxygen, nitrogen, CO_2 and rare gases. The range of the hydrocarbon detector may be adjusted from as low as 0-to-1 ppm up to 0-to-10 percent. Responsive time is less than two seconds. Perkin-Elmer Corp.

Circle E7 green card, last page

Process Burner Fires Oil, Gas Separately Or Together

The new Flexipro (flexible process) burner, a natural draft unit for firing process furnaces, has just been introduced.

This short, compact, readily accessible



unit can be used for either vertical or horizontal firing, and the simple, rugged, dual air register permits positive control of air flow, and excellent stability under adverse fuel-air ratios. The burner is particularly adapted to the simultaneous firing of oil and gas, for such service provides maximum availability, low maintenance and high firing efficiency. It is suitable for capacities from 2 million to 16 million Btu's per hour. Peabody Engineering Corp.

Circle E8 green card, last page

69-Page Catalog Covers Moisture Detection

The world's first complete hygrometric catalog has been released. The new 69-page, two-color publication contains descriptions and illustrations of hundreds of pieces of moisture-detection, control, and alarm equipment. Complete systems are described, as well as individual components whereby specialized systems can be built.

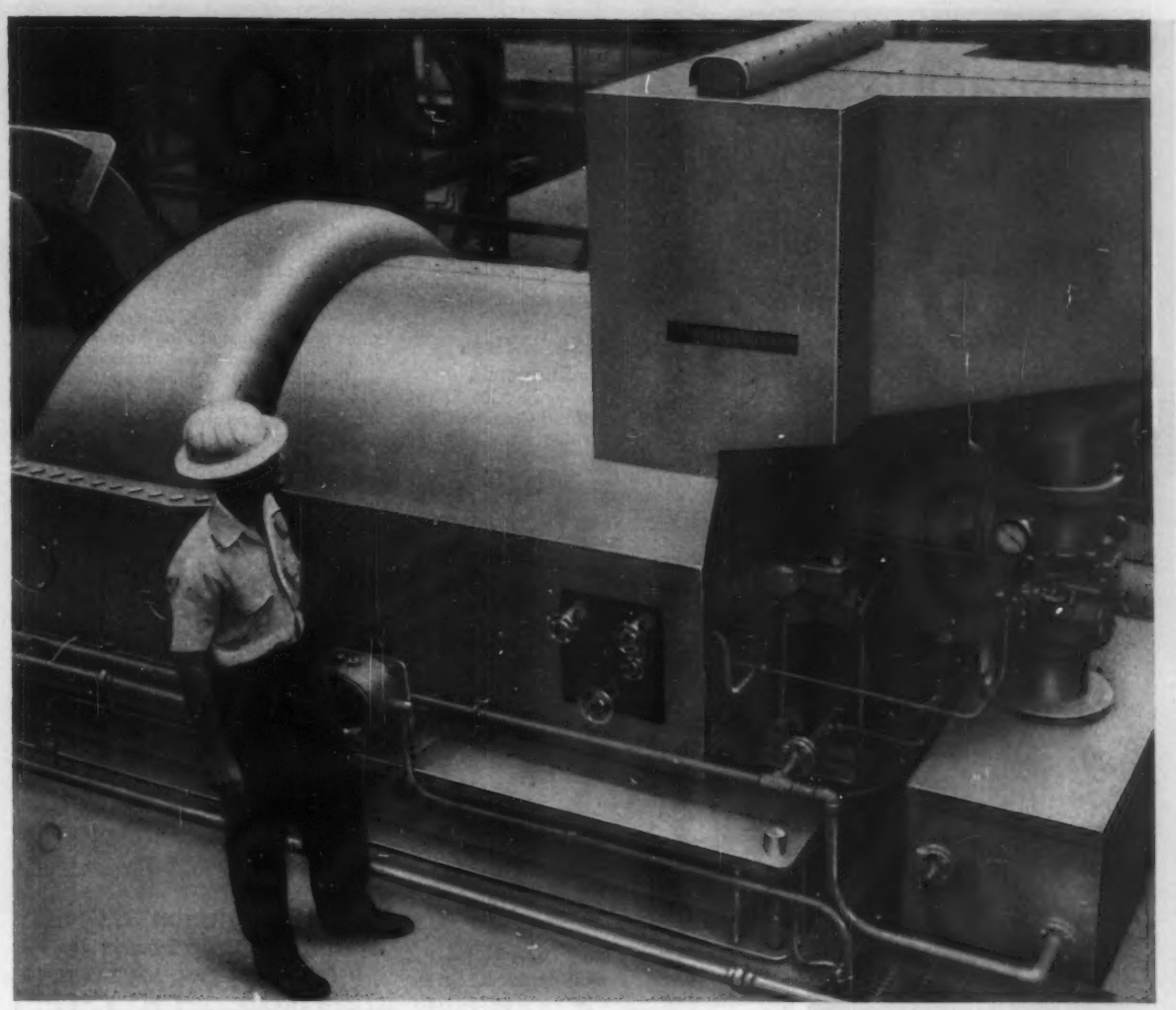
Heart of all Aminco moisture detection systems is the Aminco-Dunmore electric hygrometer sensing element—a highly-accurate commercially-available sensing element—having an inherent sensitivity of ± 0.15 percent R.H. throughout selective ranges of 2 to 99 percent R.H. Hundreds of thousands of these elements are in daily use. They respond instantly to micro-changes in relative humidity, and with proper use will last indefinitely.

Included in the new catalog is equipment for the measurement and/or recording of relative humidity, dew point, and moisture content. Individual instruments include: indicators, industrial and laboratory controllers, recorders, nondestructive package inspection equipment, etc. The American Instrument Co.

Circle E9 green card, last page

Booklet Has Practical Hints On Pipe Connections

A fully illustrated 16-page booklet describes the applications and benefits of the new W-S Fishmouth, branch pipe connector. The booklet covers cost comparisons, engineering design data, points



Westinghouse multi-stage, hi-speed turbines guarantee you

...engineered power to meet your exact needs

Why pay for power you can't use? Or, by the same token, why strain a machine beyond its capability? Westinghouse can meet your exact turbine requirements with the world's broadest line of wheel sizes and design capabilities for steam conditions through 2400 psig—1050° F at the throttle, exhausting from 1 in. hg absolute to 300 psig.*

Fitting the right wheel size to the job is the key to efficiency and economy. By knowing your process requirements, cost of steam and number of hours you expect your turbine to run during the "payoff" period, we can provide the turbine design best suited to your power and economic requirements.

To meet these varied requirements, Westinghouse has available five frame sizes of multi-stage, hi-speed turbines with wheel diameters ranging from 12 in. to 32 in. In addition, interchangeability of many wearing parts saves you money on inventories and stocking of spare parts.

Westinghouse turbine specialists located throughout the country are available at all times to provide personal attention to your heat balance problems, and are equipped to offer on-the-spot price and performance data for this entire turbine line. The capabilities of the world's largest and most modern small turbine facility are at your disposal. Call your Westinghouse representative, or write Westinghouse Electric Corporation, Small Turbine Sales, Lester Branch Post Office, Philadelphia 13, Pennsylvania. J-50605

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Turbine Frame	M-12	M-16	M-20	M-25	M-32
Number of Stages			As Required		
Wheel Size, in.	12½	16	20	25	32
Maximum hp	4000	5000	7000	10,000	16,000
Maximum rpm	16,000	12,500	10,000	8000	6000
Maximum P_1, psig	1500	1500	1500	1500	1500
Maximum T_1, °FIT	950	950	950	950	950
Maximum P_2, psig	300	300	300	300	50
Exhaust Size, in.	20	24	30	36	48
D. F. Exh. Size, in.	30	36	48	42 x 64½	48 x 84
Max. Inlet Size, in.	5	6	8	10	12

(For special applications, inlet steam conditions to 2400 psig, 1050° F total temperature can be accommodated.)

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For more data on advertised products, use Readers' Service Cards, last page.

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PALMER

Dial Thermometer

Check these functional features

- Direct-drive Bourdon Coil with a filled system for longer lasting accuracy.
- Stem can be placed at any desired angle and case can be rotated to most readable position.
- External calibration for zero setting.
- Unaffected by stem alignment.
- Accurate to one scale division.
- No sticking at any temperature.
- Non-corrosive case.

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Mfrs. of Industrial Laboratory, Recording and Dial Thermometers

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Equipment . . .

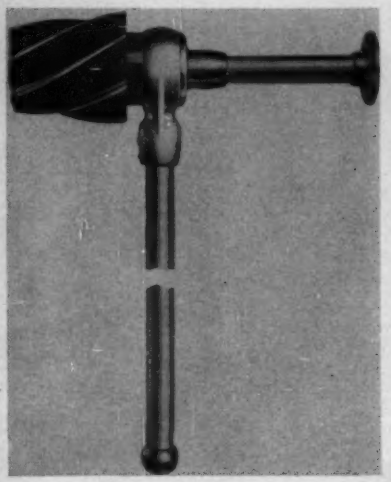
of practical use, and major benefits to your pipe shop.

Basically, the Fishmouth is the same fitting that the pipe fitter has been making himself for years. But it is considerably less expensive, consistently accurate in shape, greatly reduces on-the-job time, and winds up making a better joint. Forge And Fitting Div., H. K. Porter Co.

Circle E10 green card, last page

Pipe Reamer Smoothes Edges In Just Seconds

In just seconds the new No. 354 Spiral Reamer smooths the inside edges of 3½ to 4 inch pipe and conduit . . . eliminates



slow, costly hand filing. Ratchet handle speeds work in tight quarters. Seven spiral cutting edges pare off metal with least effort . . . no chatter. Hand grip has large pressure plate for comfortable application of body pressure when necessary. Hollow reamer construction reduces weight for easy handling and carrying ease. Hardened tool-steel cone is removable for sharpening. The Ridge Tool Co.

Circle E11 green card, last page

Valve And Fitting Gaskets Tighten On Pressure Rise

A new 12-page Bulletin, No. 4072, describes a new line of high-pressure pipe-size valves and fittings.

These valves and fittings are equipped with lens-ring gaskets and union-type joints. The lens-ring gasket is self-energizing with a pressure seal that tightens as internal pressure increases.

Leak-tight pressure systems can be made in a matter of minutes and joints can be made and unmade many times without damaging the joint. The new line has wide application in the refining and chemical processing fields where new set-ups must be made often and in a minimum of time. American Instrument Co., Inc.

Circle E12 green card, last page

Proportioning Pump Has Straight Through Design

A new, electrically-driven, positive displacement chemical proportioning pump for accurate proportioning of chemical solutions, acids and alkalies to process water in industry is the subject of a new bulletin now being offered.

Efficient and compact, the Chem-O-Feeder features a corrosion-resistant transparent plastic head, Hypalon diaphragm and check valves, and a straight-through flow design.

The two page, two color bulletin contains photographs of the Simplex, Duplex and Triplex models for proportioning up to 11, 22 and 33 gallons per hour into discharge pressures up to 125 psi. Also included are typical installation diagrams, a description of the ⅙ hp feeder and its operation, a feeder capacity chart, and a partial list of the many chemical solutions handled by the pump. B-I-F Industries.

Circle E13 green card, last page

Data Sheet Tells How To Care For Water Softeners

A water conditioning data sheet entitled, "The Care and Operation of Zeolite Softeners" has been issued.

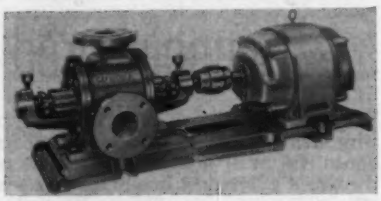
This informative technical discussion covers bacterial fouling, deposits encountered and operational factors in relation to this equipment. It tells too, how exchange materials should be handled to maintain maximum efficiency and longer equipment service lift. Betz Laboratories, Inc.

Circle E14 green card, last page

Pump Redesigned To Give Balanced Pump Loads

Important new design changes on the Apco Two-Stage Turbine Type Pumps have just been announced.

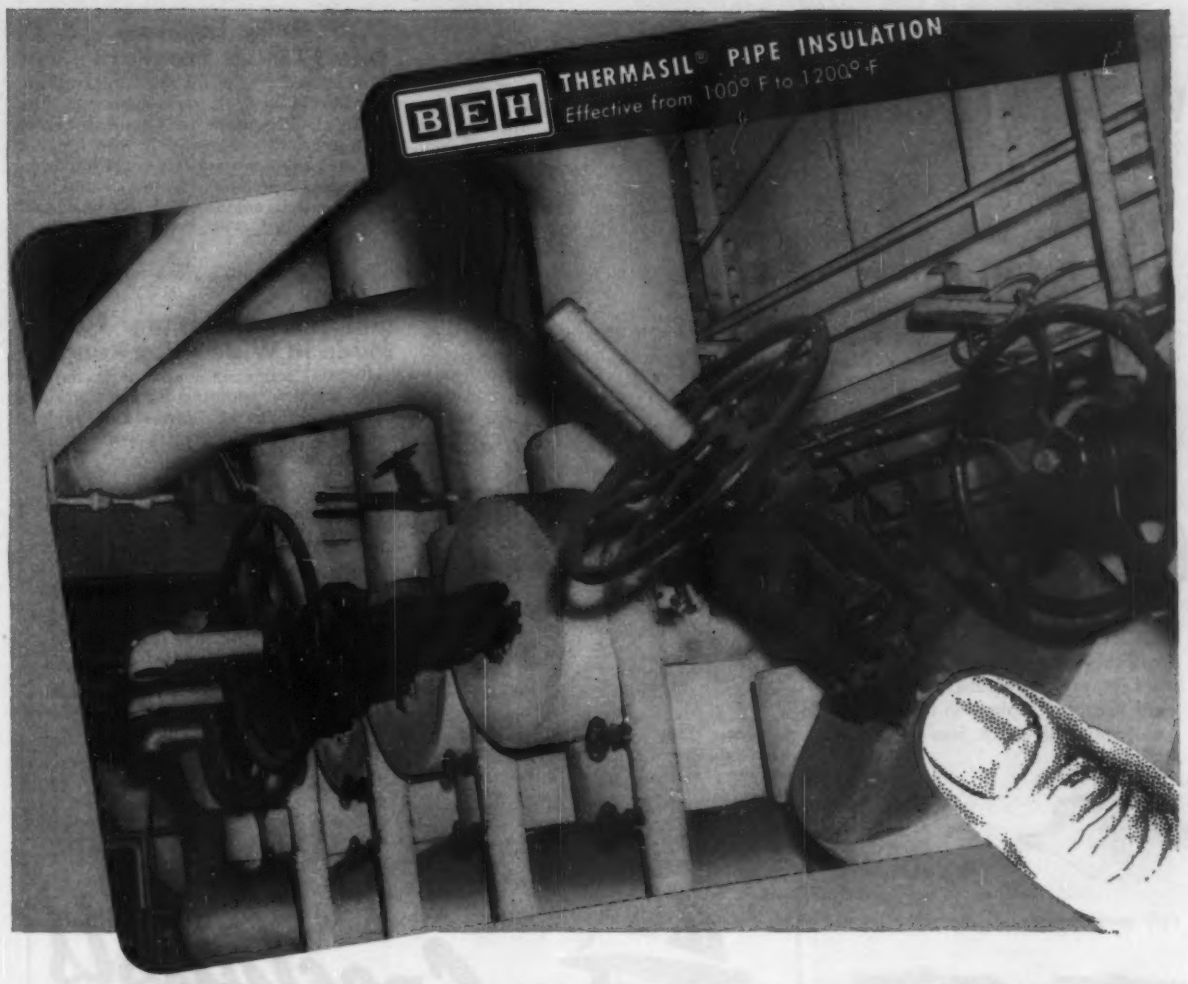
The major new feature is the revised



shell housing design which directs the fluid from the first to the second stage impeller in a 180-degree cross-over. By thus placing in opposition the resultant forces of first and second stages, the forces are equalized and a condition of balanced radial loads is achieved. At the same time, the arrangement eliminates shaft deflection.

Removable channel rings provide for easy and inexpensive replacement of eroded or corroded surfaces. Wear is reduced to a minimum by absence of metal to metal contact within the pump channel—thereby permitting the handling of free-flowing or even non-lubricating liquids almost indefinitely without wear.

Perfect two-stage hydraulic balance is



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Another famous name in the full line of Heat and Cold Insulations manufactured by

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They certainly are saving money — and you will too — with B-E-H THERMASIL calcium silicate in application, low maintenance and long service life. It is molded — not machined — to exact finished sizes. This assures that both inside and outside surfaces are tough, smooth and dust-free with dimensions held to close tolerances, providing a tight, uniform fit. THERMASIL is exceptionally light in weight, permitting easy and fast application; is readily cut, sawed, scored, drilled with standard tools — no special fabricating equipment required. It is unaffected by water or weather; has high structural strength — good for the life of the equipment it insulates. For information on B-E-H THERMASIL and other dependable B-E-H Insulations, write for catalog. Contract application service available coast to coast.

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For more data on advertised products, use Readers' Service Cards, last page.

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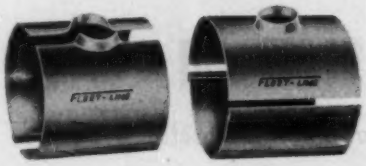
LITERATURE BY AIR MAIL...
...ask for it now.

REDUCERS: Concentric and eccentric. Nominal pipe sizes 1" to 30", ASA B16.9, ASTM A234. Schedules 10 to 160, stainless steel, and other alloys. Special lengths and sizes.

SADDLES: Conventional, and for pressure vessel heads. Nozzle sizes from ¼" to 24". Fleet-Line saddles weld neatly into place in much less time, and with much less welding rod.

Full encirclement saddles.



REDUCING TEES, Forged Steel Manifold Type.

Dealers and Stocking Distributors throughout the United States and Canada.

All orders acknowledged by air mail or long distance telephone and filled at once.

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Equipment . . .

maintained with each of the multi-vane impellers operating with double suction. All hydraulic thrust on outboard ball bearings is eliminated. Turbine type multi-vane impellers handle vapor and air along with the liquid—thereby eliminating the possibility of vapor lock within the pump.

Within each series (4, 5, and 6) the capacities can be increased or decreased merely by changing the channel rings and the impeller. The pump can be converted to right-hand or left-hand operation in the field without special parts.

Capacities of the pumps range up to 150 gpm and pressures up to 300 psi. Aurora Pump Div., New York Air Brake Co.

Circle E15 green card, last page

Bulletin Teaches Engineer Analog Computer Operation

A new brochure describes the PACE TR-10, a completely transistorized, portable analog computer.

This new computer puts the advantage of analog computation right at the engineer's desk. Accurate to 0.1 percent, it is capable of performing the mathematical operations required in the solution of 95 percent of routine engineering problems. This brochure describes how the engineer can learn to operate the computer as easily as he learned to use a slide rule. Electronic Associates, Inc.

Circle E16 green card, last page

Chart Helps Engineers Select Circuit Breakers

A revised version of the "Interrupting Capacity Chart" is now available. The chart enables users of circuit breakers to select and order the proper breaker for each application. The chart has been revised to include the newly-designed breakers designated as the JK, JKL, and the four Mark 75's. Westinghouse Electric Corp.

Circle E17 green card, last page

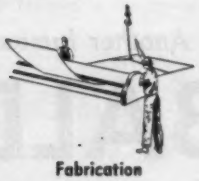
Bimetallic Exchanger Tubes Made In Wide Alloy Range

Bimetal condenser and heat exchanger tubes are now manufactured in a variety of combinations of ferrous and nonferrous metals and in a considerable range of diameters and lengths.

Major applications for Bimetal tubes are found in the chemical and petrochemical industries where their use can give reductions in operating and maintenance costs by cutting corrosion problems, giving additional structural strength, and eliminating much expensive replacement and downtime costs for heat exchangers. Construction of Bimetal tubes allows the choice of internal and external metals that best suit the particular corrosive environment to which exposed.

Bimetal tubes are available in combinations of cupro-nickel and other copper alloys with carbon steel, stainless steel, and aluminum, as well as tubes of carbon steel lined with stainless steel. Sizes most

Specialists
IN TANK AND VESSEL—



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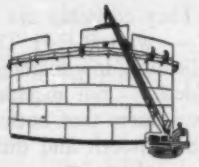
Design, Fabrication, Erection, Testing and Repairs

Tanks and vessels—from the first preliminary design to the finished job, completely tested and ready for service—are our exclusive interest. We have no other departments. Every thought is given to producing the very best tank or vessel possible. Next time, let us figure your requirements—whether it's one tank or a hundred-plus tank farm installation.



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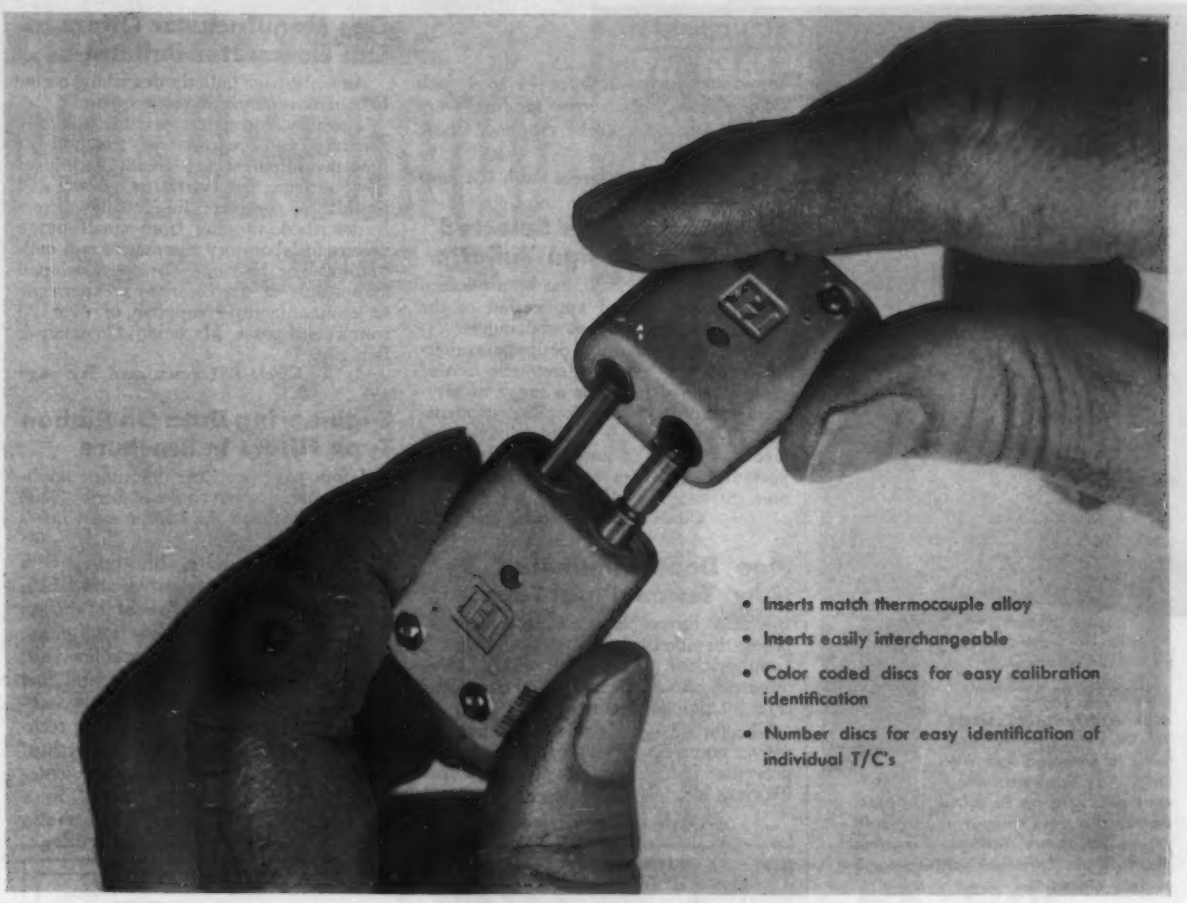
• Inserts match thermocouple alloy
• Inserts easily interchangeable
• Color coded discs for easy calibration identification
• Number discs for easy identification of individual T/C's

NEW *QuiK-Konnect** thermocouple components

For accurate, swift, and foolproof connection of thermocouples to extension wire

New *QuiK-Konnect* plug and jack bodies give fast, easy, and foolproof extension wire connections in plant, laboratory or test cell installations.

Inserts have different diameter positive and negative poles, for foolproof connection . . . are extremely easy to remove for field calibration change or replacement. Various tube adapters are available to protect small-diameter thermocouples, and cable clamps can be supplied to protect extension wires from fraying or tearing.

The *QuiK-Konnect* line, in addition to plugs and jacks, includes:

1. Single-jack panel that fits ¾-in. knockout.
2. 4-point jack panel that fits standard electrical outlet box.
3. Multiple jack strips.
4. Custom-built multiple jack panels.
5. *QuiK-Kords** for patch programming multiple jack panels.

You can get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

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For more data on advertised products, use Readers' Service Cards, last page.

SKINNER-SEAL
PIPE JOINT CLAMP STOPS LEAKS
at joint where pipe is screwed into fitting

SKINNER-SEAL
PIPE JOINT CLAMP stops leaks at joints where pipe is screwed into fitting. Any temperature—any pressure up to 2,000 pounds. Saves the cost of tearing out and renewing leaky fittings. Prevents shutdowns. In stock at most oil supply stores.

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EMERGENCY PIPE CLAMPS for safe, sure, lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12" for steel and C.I. pipe. Stocked by practically all oil supply stores.

Complete line of Repair Clamps. Send for Catalog 54!

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

Equipment . . .

commonly used are from ⅝ to 1 inch OD, although diameters ranging from ⅜ to 6 inch OD can be supplied. Chase Brass & Copper Co.

Circle E18 green card, last page

Heat Exchangers Selected Easy Using Design Bulletin

A new bulletin, B-20, has been released to cover design and application of the company's standard heat exchangers.

Complete mechanical design, also thermal rating tables, allow easy selection of these standard units for a range of services, including heating, cooling, condensing and vaporizing. Standardization of mechanical design and price offers important advantages and savings to the user. Struthers Wells Co.

Circle E19 green card, last page

Pipe Dope Eliminated By New Teflon Pipe Tape

Teflon thread tape to provide leakproof threaded pipe joints for UPVC (unplasticized polyvinyl chloride), stainless steel, aluminum and other corrosion-resistant piping, is now available.

The thread tape is unaffected by corrosive materials, is self-lubricating and prevents joints freezing. Tube Turns Plastics, Inc.

Circle E20 green card, last page

Gas Manufacturer Offers Lab Flowmeter Bulletin

An eight-page bulletin describing a new line of flowmeters is being offered.

The new flowmeters provide a highly accurate and reproducible method of flow measurement for a wide variety of flow ranges, for various gases and liquids. A complete line of flowmeters is described, ranging from small purge meters to laboratory rotameters and calibrators. The instruments were developed as a result of the company's experience as a manufacturer/supplier of over 90 compressed gases. Matheson, Coleman & Bell.

Circle E21 green card, last page

Engineering Data On Ribbon Type Filters In Brochure

A four-page brochure describing applications and characteristics of Series 2,200 Microbon Ribbon fluid filter elements is now available.

The new brochure, illustrated with photographs, drawings, curves and tables, discusses the application of Microbon elements in various liquids and gases, including hydraulic oil, gasoline, air, lubricating oil, water, kerosene and fuel oil, as well as many others.

Filtration principles and cleaning techniques of this filter media are described and illustrated in detail, and representative flow rate data is presented in a series of graphs. The new brochure also

Step UP with Gardsman
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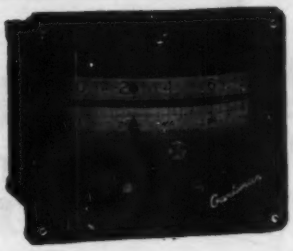
PROPORTIONING TEMPERATURE CONTROLLER



CONSISTENT ACCURACY!

This *tube-free* instrument brings many advantages over *any* on-off controller. *Anticipates* temperature change, tends to stabilize at *closer* tolerance. Cuts rejects, maintenance; ends adjustment, tube-replacement. Reliability *Guaranteed.* Write for Bulletin JP-1.

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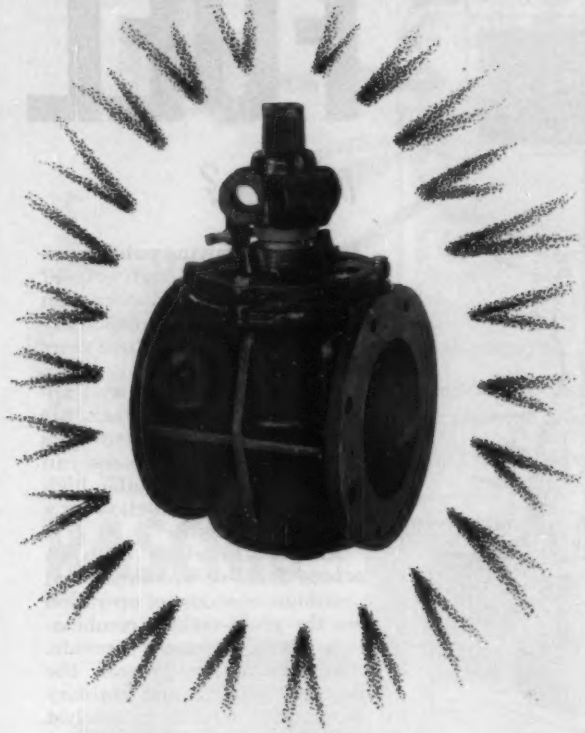
DeZurik
PLASTIC-COATED VALVES!



low cost protection on mild corrosive services!

Iron body DeZurik Valves with plastic coating now provide corrosion resistance on mild corrosive services that formerly required special alloy valves.

And plastic-coated DeZurik Valves cost only slightly more than standard iron body valves. Sound like the perfect valve for salt water, alkalies and mild acids? They are!

Get more information from the DeZurik representative in your area, or write Dept. PC.

DeZURIK CORPORATION
SARTELL, MINNESOTA

So SIMPLE that "Specials" are Likely to be Standard!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol

MAGNETROL

The World's Most Dependable

LIQUID LEVEL CONTROL

Because of the utter simplicity of Magnetrol's magnetic operating principle, standard models can be easily adapted to meet any special requirements for pressure, temperature or corrosive liquids . . . and usually at little extra cost. This Magnetrol versatility has solved all kinds of tough level control problems . . . and given our engineers wide application experience that can be invaluable to you.

Magnetrol is so simple that failure is all but impossible! Using only permanent, unfailing magnetic force for its operation, there's nothing to wear out . . . no diaphragms or bellows to stiffen and rupture . . . no electrodes to short or corrode . . . no packing to bind or leak. Magnetrol is practically maintenance-free! Magnetrol units are available for controlling level changes from .0025-in. to 150-ft. . . . with multi-stage switching when desired. Send coupon for full details.

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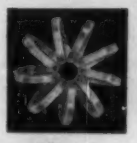
Partition Ring

Spiral Ring


Plastic Tellerette

Lessing Ring

Raschig Ring

Ceramic Berl Saddle

SPECIALISTS in Tower Packings

Here are several types of tower packing made in one of the Knight plants, the largest in the country specializing in tower packing production.

Knight packing includes the popular and efficient Berl Saddles made of unglazed porcelain and chemical stoneware. Both are sturdy, nonspalling and entirely acid proof. Berl Saddles, made of Permanite or steel, are available for use with strong caustic solutions or HF.

Knight makes other tower packings — including Raschig, Lessing, spiral, and partition rings. We also furnish the new polyethylene Tellerette packing shown.

Data concerning sizes, weights, surface area, etc., on our various types of tower packings is given in Knightware Chemical Equipment Bulletin No. 11 — Write for your copy.

See us in space #586 Exposition of Chemical Industries in New York

Maurice A. Knight
956 Kelly Ave., Akron 9, Ohio

KNIGHT-WARE CHEMICAL EQUIPMENT

Equipment . . .

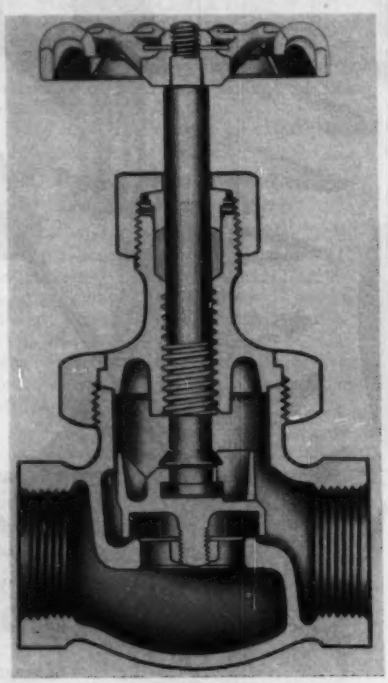
lists standard sizes and tolerances available. In addition, a group of drawings illustrates typical means of installation. Filter Div., Bendix Aviation Corp.

Circle E22 green card, last page

Check And Globe Valves Eliminate Screwed-In Seats

Two new lines of bronze valves have been introduced.

The valves are: No. 229 C 200-pound bronze globe valve and No. 239 C 200-pound bronze lift check valve. They are



available in sizes ranging from ¼ through 2 inches.

The new valves have integral body seats with a semi-crown face instead of screwed-in seats as was the case in the valves they replace.

The disc holder on the new globe valve is of the slip-on type. No threaded disc stem ring is employed. The slip-on disc holder makes for fast and easy repair by either the insertion of a new composition disc or the replacing of the disc holder and disc as a complete unit.

The valves are regularly furnished with No. 4 Cranite discs. This disc is suitable for high pressure steam up to 450° F. When ordered for cold water, air, gas, oil, or gasoline, the valves are furnished with a No. 6 disc.

No. 4 Cranite disc is laminated and consists of a synthetic base with spirally wound long fibre asbestos and other ingredients. They are cured to provide a hard disc for high temperature, yet they seat with a minimum of effort.

The No. 6 disc is made of a specially formulated composition consisting of a synthetic base. They are soft enough to

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FUEL

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Has the fuel-buying public turned up its noses at high octane? Not on your life. And more than 15 million high compression engines built in the last three years say they won't.

That's why refiners who are using the simple, flexible HOUDRIFORMING and ISO-PLUS HOUDRIFORMING processes can look forward to profitable high octane gasoline production for a long time to come.

Maximum yield of high octane fuels or aromatics and maximum economy of operation are the profit-making combination these processes provide. And with either process, the superior activity and stability of Houdry reforming catalyst also means lowest catalyst cost per barrel of throughput.

The reason for this profit-power in Houdry processes and catalysts is people. When you work with Houdry, you're getting the services of pioneers in catalytic processes. It's the close, careful, shirtsleeve-kind of service only possible when people all but eat, sleep and live catalysis. And the advantages are all yours.

*

HOUDRY CATALYSTS

*Houdry means Progress . . . through Catalysis

HOUDRY PROCESS CORPORATION

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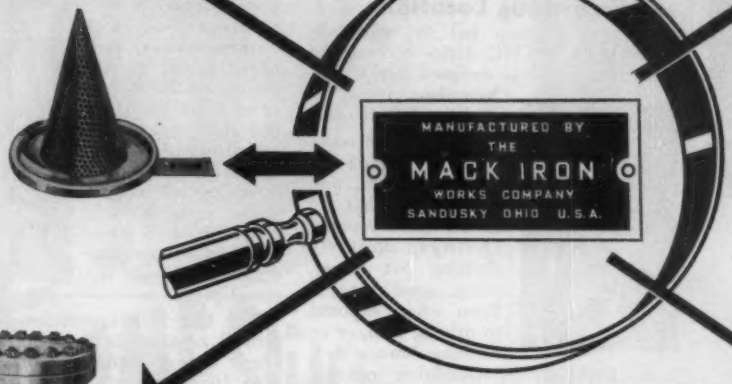
LITTLE TAG . . . BIG MEANING!

Not a mere name plate, this little metal tag on a piece of equipment is unreserved assurance of quality workmanship and dependability of service . . . *priceless characteristics not solely measured in dollars and cents.*



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Stock and custom made items for many engineered applications which involve pumping of fluid materials and operational liquids.

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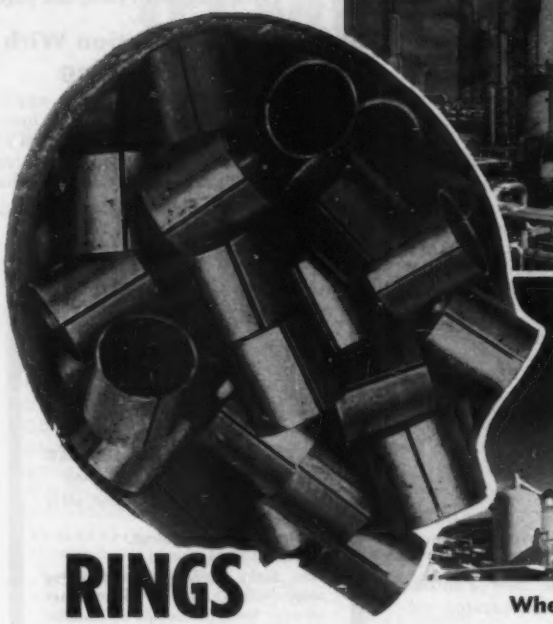
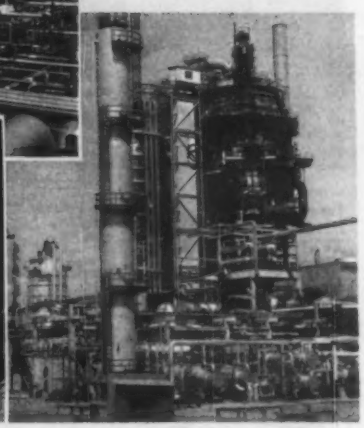
RASCHIG

Metal RASCHIG Rings For Tower Packing

Sizes ⅜" thru 3"
IN STEEL, ALLOY OR OTHER METALS





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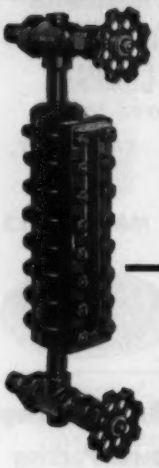
Get the LEVEL READINGS of LIQUIDS THAT BOIL and Flash



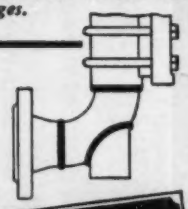
Jerguson Large Chamber Gage

The Jerguson Large Chamber Gage is designed to indicate the level of liquids whose tendency to boil and flash makes an accurate level reading impossible with ordinary gages.

The chamber of this Jerguson Gage is of such large diameter that the level is not badly upset by boiling action of the fluid. This makes possible close level readings, the kind you want and need for accurate control and safety.

You don't have to be satisfied with gages that require guessing at level readings. If liquids boil, install Jerguson Large Chamber Gages and be sure of the liquid level.

The Jerguson Large Chamber Gage is available in reflex and transparent types. Write for full information on this and other Jerguson Gages.



Tapped ¾" pipe threads standard. Available with 2" flanged ends for direct connection to vessel.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

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100 Adams Street, Burlington, Mass.
Offices in Major Cities
Jerguson Tress Gage & Valve Co., Ltd., London, Eng.
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See Booths 1211-1213, Chemical Show

Equipment . . .

make a tight seat on air or gas, yet resistant enough to withstand hot water, and the wear and tear of repeated operation. Crane Co.

Circle E23 green card, last page

Condulets Operate Safely In Hazardous Locations

Torrents of rain fail to break the safety seals of EWC Series control and indicating stations, designed for use in hazardous areas, indoors and outdoors.

Joints of the cover opening, threaded operating shaft, and pilot light jewels are sealed with Neoprene O-rings; effectively shutting out fumes, dusts, and water. Even when exposed to driving rain, or to washing down with a hose, EWC Series Condulets operate safely.

The new Condulets are available in one, two, or three-gang pushbutton stations, pilot lights, and selector switches; and are designed for use in Class I, Groups C and D (NEMA 7), and Class II, Groups E, F, and G (NEMA 9) hazardous locations. Crouse-Hinds Co.

Circle E24 green card, last page

Painted Grating Resists Acid Solution 72 Hours

A new paint process that increases steel grating resistance to wear, abrasion, corrosion, chemicals, and weathering has just been developed.

This new Ponbake process provides a rugged, durable finish that can be applied to any of the firm's special or standard grating products if specified.

In the new finishing procedure, grating is cleaned and phosphatized in one operation. Then, an epon base, high polymer synthetic paint is applied through a "flowkote" method which assures complete coverage to 1-mil minimum thickness. Finally, the grating is baked at 350° F to cement the bond between paint and metal.

Comprehensive tests have proved durability of the grating's finish—a mixture of xylel, epon resin, and color pigment.

The epon-base grating paint performed well in weatherometer tests equivalent to 3½ years of exposure in a salt-laden atmosphere area. In a check for abrasion resistance, the steel grating was bombarded with No. 6 heavy gravel for 40 minutes—and, no bare metal showed through the special paint covering. The grating, coated with the new Ponbake process, has withstood concentrated sulfuric acid and sodium hydroxide (caustic soda) for several hours, and 5 percent sulfuric acid and sodium hydroxide solutions for 72 hours. Blaw-Knox Co.

Circle E25 green card, last page

Improved Thermal Actuator Operates At Lower Pressure

A new, improved model of the vapor-powered Thermo-Drive actuator for electronic control systems has just been introduced.

While retaining the original thermal-release principle that positions final control elements without compressed air, motors, gear trains, pumps, oil amplifiers, or relays of any kind, the new device is characterized by several design refinements which permit stroke and zero adjustments, and provide full operating thrust with lower internal pressures.

The first field installation of the improved actuator is in operation at the Clark Oil & Refining Corp. plant in Blue Island, Ill.

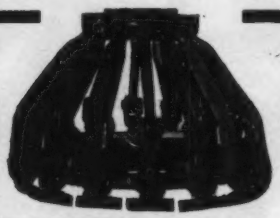
The latest model of the Thermo-Drive remains a simple device with only two moving parts. An electrical resistance strip heater vaporizes a liquid at a continuous rate. The pressure of the vapor drives a diaphragm against the valve actuating stem.

The Thermo-Drive actuator develops 300 pounds of thrust and has an adjustable stroke span of .5 to 1.5 inches. Response speed is 0.1 inch per second. An explosion-proof housing makes it suitable for Division I locations. The Swartwout Co.

Circle E26 green card, last page

Galvanized Protection With Paint-On Zinc Coating

Savings of up to 50 percent in application time are predicted for a new inorganic zinc coating because it cures itself to full hardness without the need for applying a separate curing solution. The



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Fills, seals, stamps and counts lug cover pails. Output of 15 pails per minute. Write for details on installation to meet your requirements.

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SAFE AND SURE WITH GENTEX PETROLEUM SAFETY HATS

Slings in Gentex Safety Hats use same design principle as slings in Gentex jet flight helmets. 6-pt. suspension, 3-layer crossover at crown. Rugged polyethylene shell exceeds all Federal Safety specifications, yet the Gentex weighs within ¾ ounce of any safety hat made. No metal parts — fully non-conductive.

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Instantly adjustable, snap-in suspension sling, well-ventilated construction insure comfort for every wearer. Good-looking, too — impregnated colors can't chip or flake. Available in green, gray, white, blue and yellow — in both hat and cap models. Examine the Gentex Safety Hat for yourself.

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NOW COMPLETE AUTOMATION IN TANK GAUGING!

You can eliminate hand gauging completely with the new Gilbarco electronic Tank Gauge because this gauge measures *both product level and water interface.* At the turn of a switch the sensing element, which tracks product level, will penetrate the product to also measure water bottom. Readings of both levels can be made at the tank base or remotely on a Gilbarco Null-Balance Receiver. Gauges already installed can be equipped for this dual operation quickly, easily, inexpensively. Write for full information on the *only* gauge which gives you complete gauging automation.

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• RESISTANT TO THERMAL SHOCK

Scientifically compounded to "take it," Patterson Arlcite Spheres for fixed bed support and hold-down material in refining processes assure no contamination of valuable catalysts. Chemically inert and non-absorptive, these smooth-surface high alumina balls have highest resistance to thermal shock.

Arlcite Spheres offer the ultimate in mechanical strength—resistance to crushing, erosion and abrasion—and *maximum economy*, too. Field installations have extended over two years to date without replacement. Write us for the facts!

ARLCITE 86-8 Spheres are available in the following sizes: ¼", ⅜", ½", ¾", 1" and 1¼". Immediate shipment.

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FERRO CORPORATION
East Liverpool, Ohio

Equipment . . .

new product, called Zinkote, is applied over bare steel by brush, spray or roller. A single coat only a few mils thick gives complete protection to steel surfaces exposed to water, severe weathering, salt spray and abrasion. Film thickness is not critical.

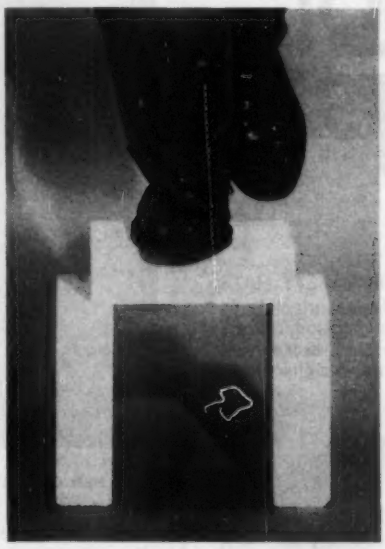
Zinkote has excellent adhesion, bonding both physically and chemically to the steel. It may be used wherever galvanizing is suitable, and in many ways offers more permanent, positive protection. Unlike galvanizing, however, it may be applied to steel structures or members of any size, before or after erection, with regular painting equipment. There is no need to dismantle and ship sections to another location for zinc protection.

The coating sets hard and water resistant in a few hours, and achieves maximum water resistance in several days. Being completely inorganic, it is not affected by organic solvents and not subject to common types of failure experienced with paints and organic coatings. Amercoat Corp.

Circle E27 green card, last page

65 Percent Strength Increase In New Firebrick

A stronger and improved insulating firebrick that is both the lightest in weight and the lowest in thermal conductivity of any firebrick available today has just been placed on the market.



The mechanical strength of the refractory has been increased by more than 65 percent for the B&W K-20 and by more than 50 percent for the B&W K-23. This increase will enable the insulating firebrick to be used in a wider range of applications. It can be fitted with hangers or pins without danger of breakage.

In addition to its improved strength, it is the lightest weight insulating firebrick on the market. The K-20 has an average weight of 1.70 pounds per 9-inch

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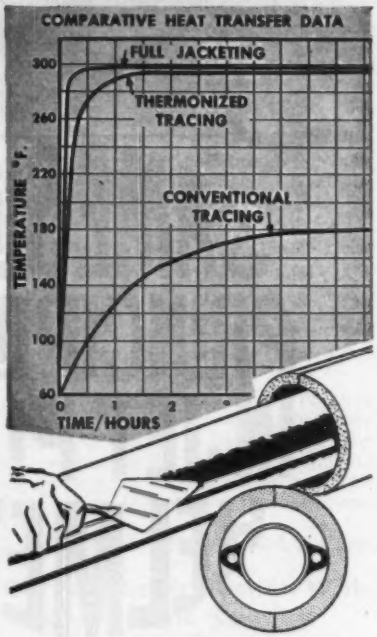
HEAT TRANSFER CEMENT
now effecting savings up to 90% for over 1,000 users!



Thermon is a non-metallic adhesive compound with highly efficient heat transfer properties, and is easily applied over either steam traced or electrical resistance systems . . . working equally well for either heating or cooling processes.

Thermonizing has excellent heat transfer characteristics (see curves), exceeding steam traced equipment approximately 1100%, and closely approaching jacketing equipment. Thermon can be used almost without exception in place of expensive jacketing (and in many applications where jacketing is impossible), with savings up to 90%.

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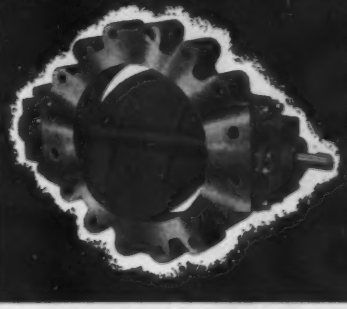
FOR MANUAL and POWER CONTROL



FISHER-CONTINENTAL Butterfly Valves fit the specifications of a vast majority of applications. They're low cost—more compact than expensive, complex valve installations. And they're easier to operate and service, too.

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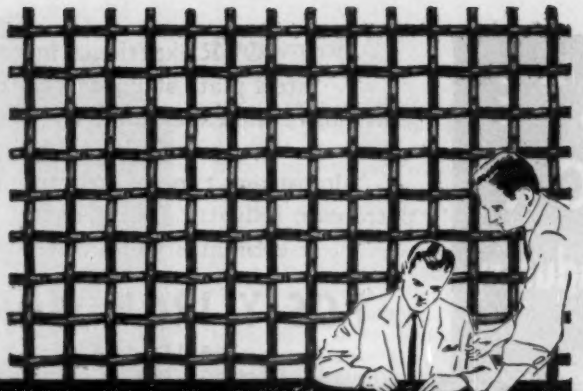

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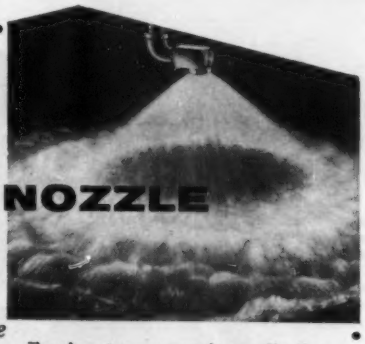

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And . . . for complete spray nozzle information, write for Catalog 24.

Equipment . . .

straight, while the K-23 9-inch straight averages 1.85 pounds—the only 2300° F use limit brick marketed today that weighs less than 2 pounds per 9-inch straight.

The "extra-strength" brick also offers a lower thermal conductivity, or "k" factor, and stores less heat than any other insulating firebrick available in its temperature range.

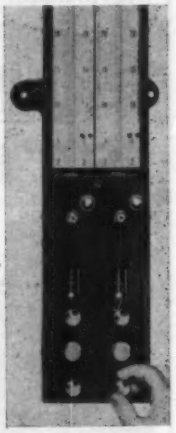
Better mortar bonding and resistance to gas erosion are other important features of both firebricks. Having a clean surface, the brick develop a better bond when laid up in a wall because the mortar holds tightly. Superior resistance to direct flame exposure enables the insulating firebrick to withstand the erosive effects of circulating gases and flame impingement, thus affording long and profitable service in a wide variety of applications.

The firebrick can be tailor-cut, drilled or shaped as necessary, eliminating the need for costly special shapes and the delays involved in obtaining them. By using only ordinary wood-working tools, these firebricks also can be cut and shaped on the job in minutes. The Babcock & Wilcox Co.

Circle E28 green card, last page

Purge Tank Gages Feature Simplified Controls

A new and completely redesigned line of remote-indicating, manometer-type, continuous-purge tank gauges has been announced. The instruments are applicable to gauging all types of liquids, from petrochemicals to water, and may be used for any size or shape vessel, open or closed, overhead or underground.



Major emphasis in the redesign has been placed upon simplification of controls and method of operation, with integral safety checks to prevent misuse. Adjustment of trickle purge, the only control adjustment required, is easily accomplished with the aid of a built-in hi-lo purge flow indicator. The indicator eliminates operator judgment as a factor of instrument performance; it unmistakably shows exactly when the purge rate has been set for highest accuracy with minimum air consumption. Periodic cleaning of the tank lines is achieved through an integral high-pressure purge; operated through a front-of-panel knob; an internal valve arrangement automatically isolates the gauge from the tank line when the high-pressure purge is applied.

Installation, too, has been simplified. The gauge requires only two air line connections for open tanks, three for

closed or pressurized tanks. Multiple-tube instruments have manifold air supplies so that only one supply connection is necessary.

The gauges are ruggedly constructed, may be located indoors or out, at transmission distances up to 600 feet from the tank. They are available in single- and multiple-tube models (up to 12 tubes), in ranges up to 60 inches. Standard scales are graduated in linear inches and tenths, can be supplied in any units of volume or weight desired. Meriam Instrument Co.

Circle E29 green card, last page

Air Operated Pipe Beveler Cuts Three Land Angles

The new Bev-L-Grinder, is designed to make on-the-job, "machine shop" accurate weld bevel preparation on 6 to 8 inch pipe.

Because it is more accurate and does not change the physical properties of steel, stainless steel, high-alloy steel or aluminum pipe, the grinder makes it possible for field crews to get the highest quality welds. The head can be set 20, 37½ and 90 degrees by a locking pin in the motor support. A 90 degree setting produces a true face for accurate land. Other angles are available by locking grinder head with socket head cap screw.

Cutting action is fast, accurate and easy to control. The operator simply rotates grinder head around a self-centering spindle. There is no fighting the grinder as it rotates freely in fixed plane. Good balance permits one hand control.

Guarded 6 inch cupped grinding wheel is powered by a 6,000 RPM air motor. The E. H. Wachs Co.

Circle E30 green card, last page

Centrifugal Compressor For Low-Flow, High Pressures

A completely-new line of centrifugal compressors has been developed to meet a long-standing need in low-flow, high-pressure ratio applications.

Available in both single and two-stage designs, they feature simplicity, flexibility in materials of construction, and adaptability to handling gases other than air. Important advantages are freedom from vibration or flow pulsations, light weight, and small space, and the ability to provide oil-free air. Only a simple, inexpensive foundation is needed. Capacities range from 800 to 8,000 cfm, pressure to 1,000 psia.

STOP!

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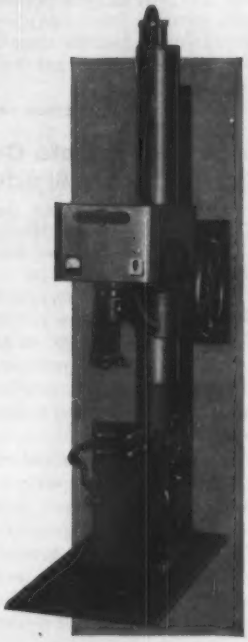
with an **INDEPENDENT**

Model "200"

Valving Machine



Insertion or removal of Gas Cylinder Valves or similar threaded units, such as I.E.CO. Test Plugs used with Hydrostatic Gas Cylinder Testing Equipment, is done by a simple turn of a Control Knob which directs the rotation of the Valve Wrench. The machine can quickly be adjusted for cylinders of diameters from 3 through 16 inches and heights of 10 through 60 inches. Available for 110-220 or 440 volt installation.

The Model "200" Valving Machine is compact — requires only 8 square feet of floor space.

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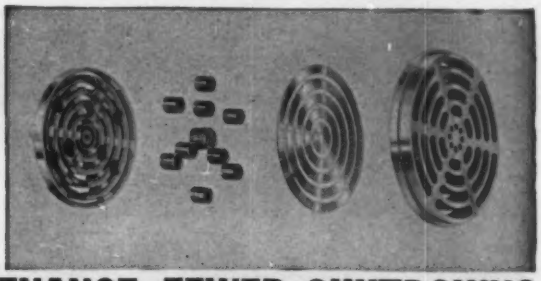

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- **quiet, vibration-free • utmost safety • lower operating costs**

VOSS VALVES are made to specification, machined from solid stock (not cast)—using best alloy steels; for corrosion condition—stainless steels, such as 410, 18-8 or non-ferrous alloys—monel, inconel, etc. PLATES are machined (not stamped) and ground for precise close tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

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J. H. H. VOSS Co., Inc.
785 East 144th Street, New York 54, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

Equipment . . .

The Type R compressor line introduces a new design concept. The cast casing and forged impeller element can be made of materials selected to meet application needs. Special bearing housings and seal designs permit lubrication with water or other lubricants, and obviate explosion hazards caused by oil contamination or toxic gas leakage. Elliott Company.

Circle E31 green card, last page

Engineering Data On Ribbon Type Filters In Brochure

A four-page brochure describing applications and characteristics of Series 2,200 Microbon Ribbon fluid filter elements is now available.

The new brochure, illustrated with photographs, drawings, curves and tables, discusses the application of Microbon elements in various liquids and gases, including hydraulic oil, gasoline, air, lubricating oil, water, kerosene and fuel oil, as well as many others.

Filtration principles and cleaning techniques of this filter media are described and illustrated in detail, and representative flow rate data is presented in a series of graphs. The new brochure also lists standard sizes and tolerances available. In addition, a group of drawings illustrates typical means of installation. Filter Div., Bendix Aviation Corp.

Circle E31 green card, last page

Refractometer Measures And Controls Process Liquids

A new process refractometer for automatic, continuous measurement and control of organic and inorganic liquids has just been announced.

The instrument has been designed for industrial production or research application in the analysis of stream or batch processes, the measurement and control of product quality, and for a variety of other problems in quantitative analysis of liquids. It employs the principle of measurement of variations in refractive indices between the substance analyzed and a constant standard.

Wide range flexibility, easy conversion to new problems, and rapid response are claimed as outstanding advantage of the instrument. Measurements of ranges as narrow as zero to one percent, and as broad as zero to 100 percent, can be accomplished. Provision is also made for handling of suppressed-zero ranges with an accuracy of one percent within extremely narrow limits. The refractometer can be readily converted in the field from one problem to another; or from one range to another of the same substance. Readings can be obtained of 90 percent of full-scale deflection within 30 to 60 seconds.

Construction of the instrument for industrial requirements features unitized design of the amplifier, optical bench, and control unit. It is available in either explosion-proof cases, or in non-explosion-proof vapor-tight cases. Mines Safety Appliance Co.

Circle E33 green card, last page

175 ppm Dissolved Water In Kerosine Turns To Ice

The relatively new air hazard of water dissolved in kerosine-type fuels can cause jet engine flameouts in the cold upper air, according to a new brochure just released.

The eight-page booklet points out that kerosine fuels have, even more than gasoline, the ability to dissolve water. It also states that water, fully dissolved in the fuels at ground temperatures, is released as free water subject to ice formation when the temperature goes well below zero at cruising temperatures.

Highlighting the stature of the problem, the booklet shows that 10,000 gallons of fuel containing only 175 parts per million dissolved water—and no free water—at ground temperature can still yield enough free water at —50°F to form more than ten pounds of ice.

Molecular sieves have demonstrated a capacity for water that is from five to twenty times that of older-type desiccants.

Known as synthetic zeolites, molecular sieves derive their adsorbent properties through billions of tiny pores that will admit a molecule of water and reject the larger hydrocarbon molecule of fuel. They do not, thus, co-adsorb fuel as do the common silica and alumina desiccants.

Type 4A Molecular Sieves are recommended for fuel drying. These have pores about 4 angstroms in size (about sixteen billionths of an inch). Regeneration in place permits the molecular sieves to be used over and over. Linde Co.

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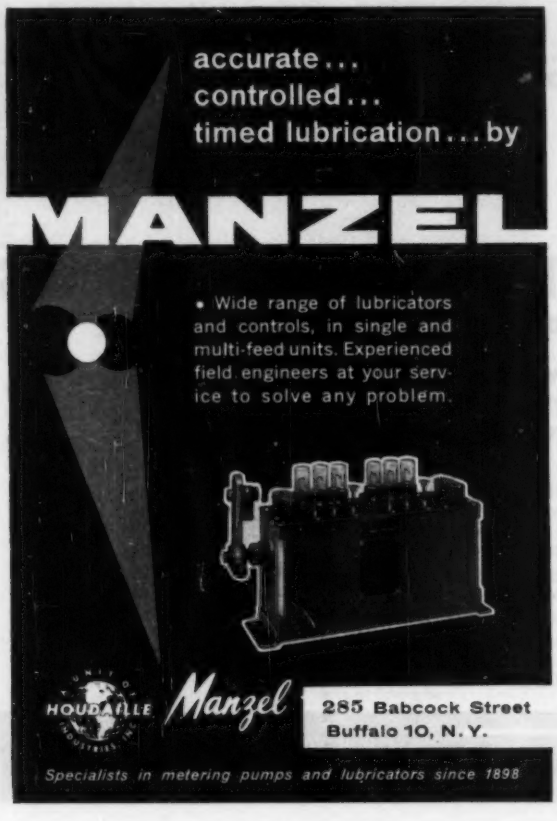
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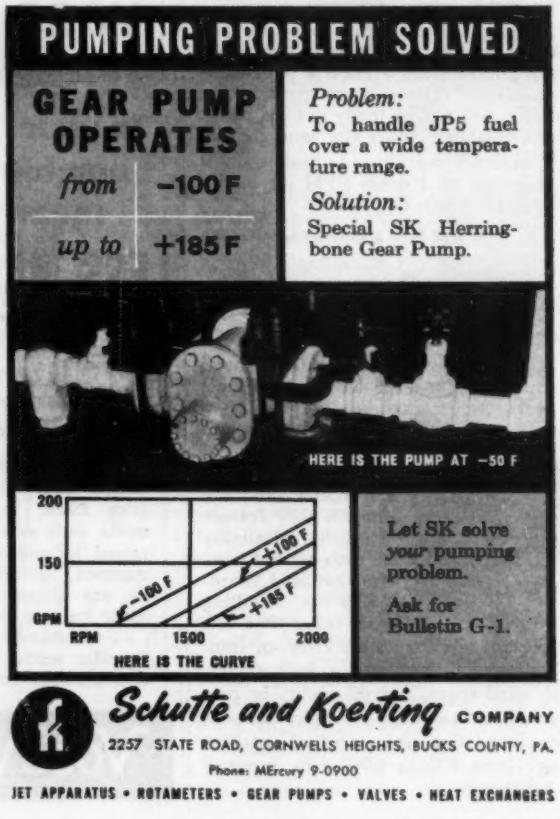

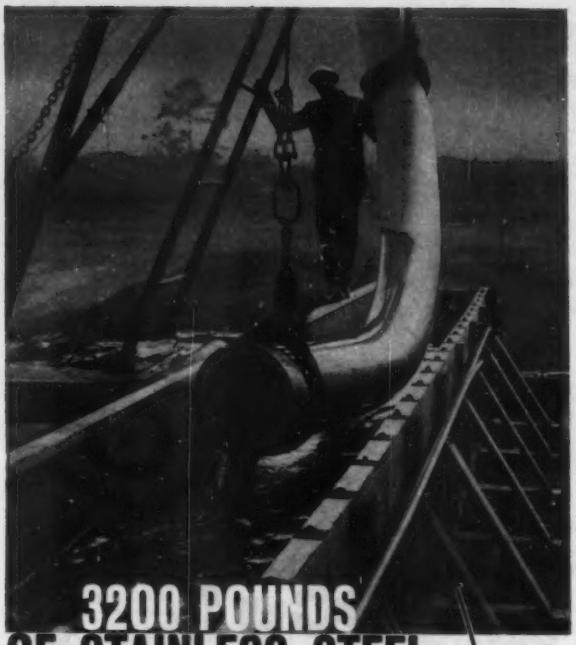

3200 POUNDS OF STAINLESS STEEL

CLEAN AS CLEAN CAN BE

The 3200 pound, 16 foot stainless steel pipe section shown above is an example of the piping to be used in the nation's largest atomic power plant. The pipe was fabricated in Houston by Southwest Fabricating and Welding Company. Before being shipped, every inch of each pipe section was thoroughly inspected to be sure that it was completely free of all dirt, mill scale, oxides, metal elements, and similar deposits. There could be no guesswork. *The pipe had to be hospital clean.* To guarantee that their piping was as clean as clean could be, Southwest called in the Nowery J. Smith Co.

The Smith corrosion prevention specialists have cleaned and passivated 1190 feet of the steel pipe to date. Pipe ranging to 22 inches in diameter, with wall thicknesses to 1.220 inches, was polish-blasted and then passivated to ASTM specifications to preserve cleanness.

If corrosion is a factor in the work-life of your equipment consult with the Nowery J. Smith Company during the design phase of your project. Think Nowery J. Smith Co. for Hot-Dip Galvanizing • Metallizing • Chemical Cleaning • Sand/Shot Blasting • Painting/Coatings • Plastics • Plastic Applications • Vessel Linings

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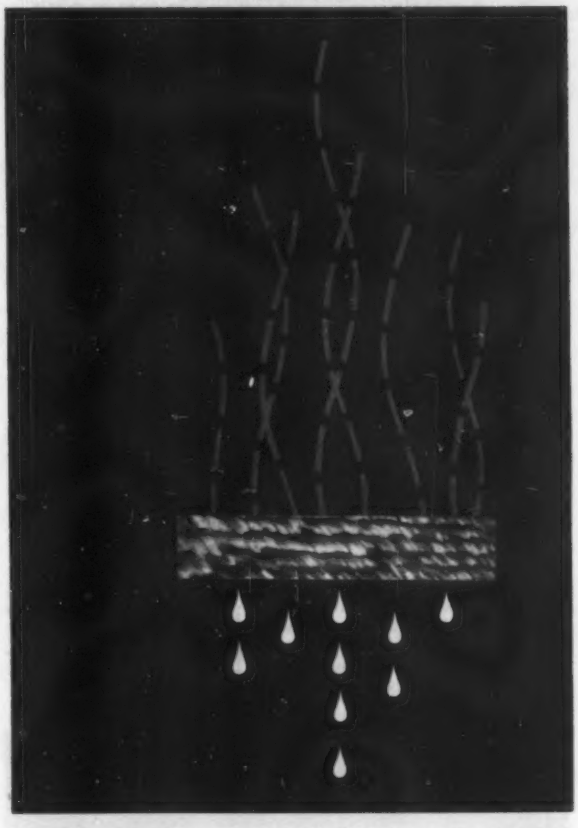
Your liquid entrainment problems are solved faster, more economically when you call on the engineering and production experience of Metal Textile. As the originators of knitted wire entrainment separators for the processing industry — Metal Textile has been consistently first in advancing the art...developing special meshes...introducing new materials...applying new techniques to meet specific application requirements. Just recently, for example, Metex has introduced entrainment separators in polyethylene—marking a new high in corrosion resistance, and fiberglass —for coalescing sub-micron particle mists. As the oldest and largest company in the field today—Metal Textile has the engineering experience—and the necessary research and production resources to back it up—to take on the most challenging entrainment problems. Our engineering department stands ready to help you solve your specific problems with complete design assistance. For latest design guides, write or call for Bulletin ME-9: Metal Textile Corporation, Roselle, N. J.



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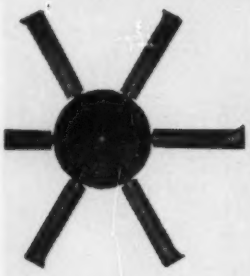

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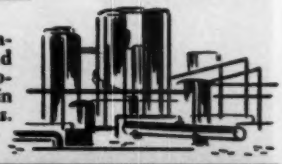

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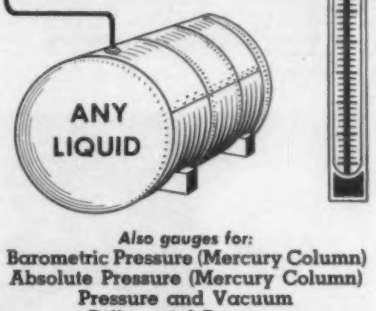

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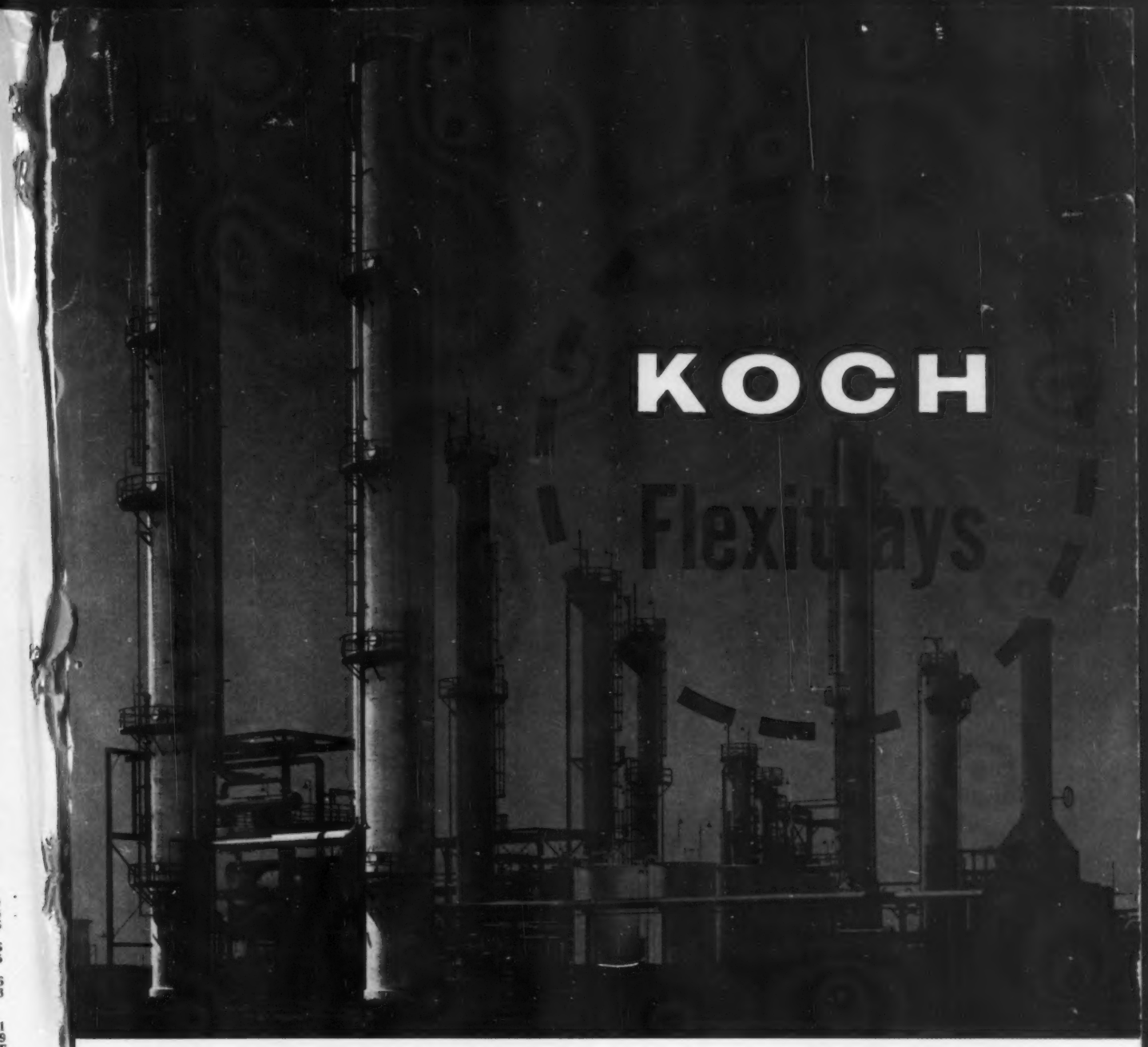

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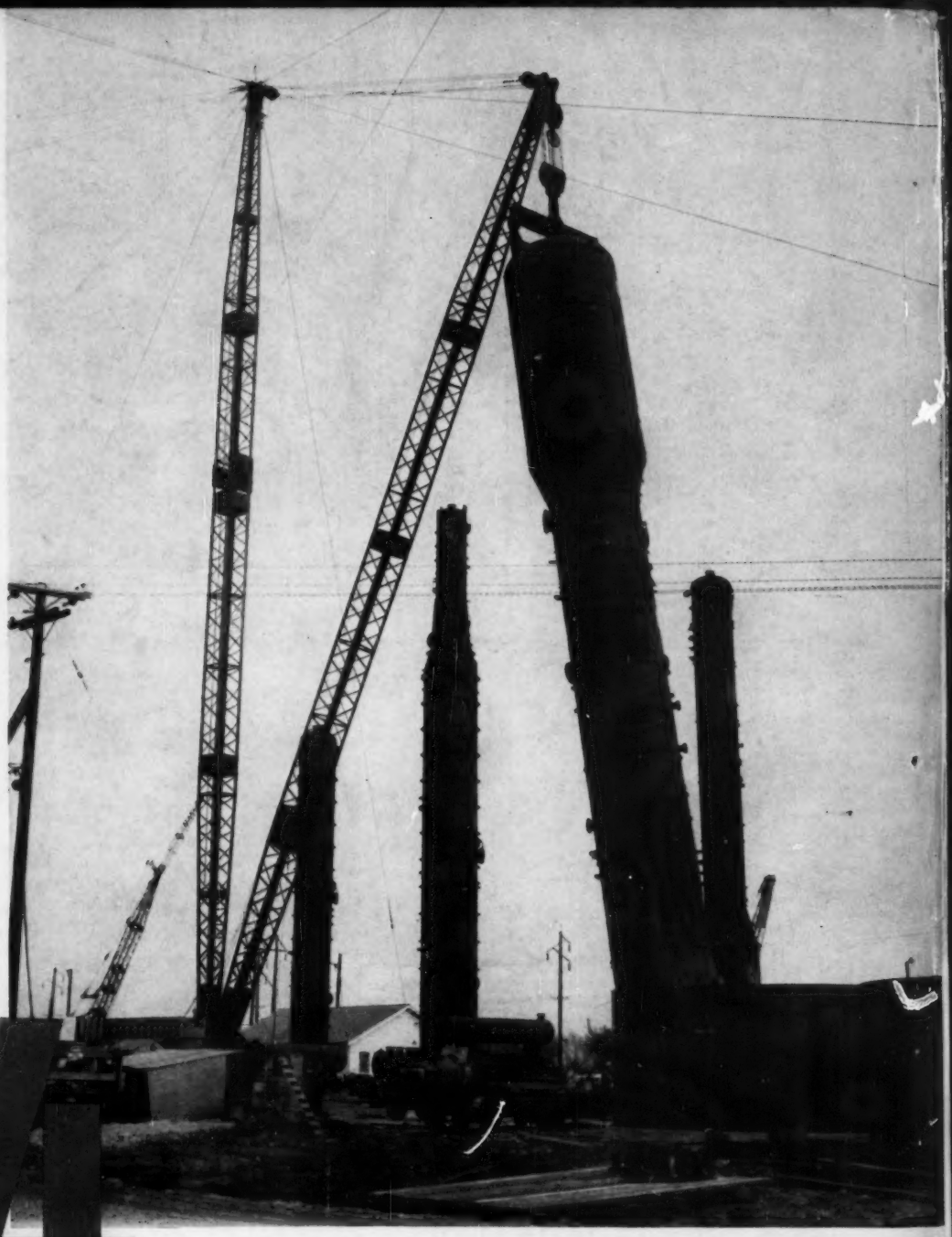

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